THE MORE IMPORTANT INSECTS AFFECTING OHIO SHADE TREES.

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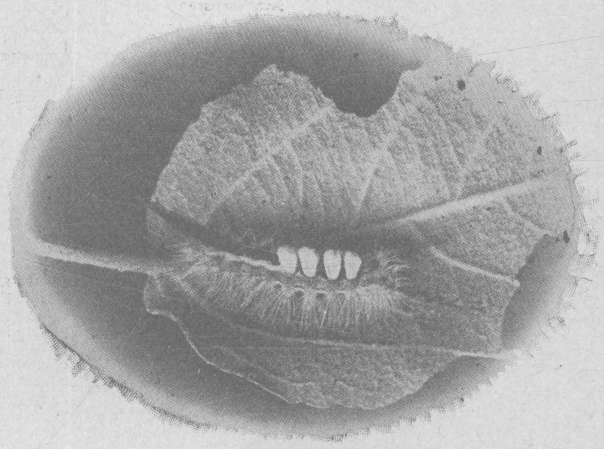

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BULLETIN

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THE MORE IMPORTANT INSECTS AFFECTING OHIO SHADE TREES.

BY J. S. HOUSER.

INTRODUCTION.

With the rapid decrease in the forest acreage of the country we are learning to appreciate trees, both for their beauty and for their value as an economic factor in our welfare; hence, the problem of their preservation is coming to mean more and more to us. Generally speaking, this decrease in the number of trees has been accompanied by an increase of the insect foes that prey upon them, both as regards numbers of species and individuals of a given species. Further, this band of depredators seems to be getting in its work more effectively in the city districts than in those more rurally situated. This publication, therefore, from the very nature of things, will be of greatest value to the city householder, but may be applied to the needs of all.

INSECT CONTROL A NECESSITY IN CITIES.

For several reasons the employment of artificial measures against shade tree insects is more nearly a necessity under conditions that exist in the cities and towns than under those found in the rural districts.

Absence of insect-eating birds.

The absence of many of the insectivorous birds partially explains the abundance of insect life in the cities. Since the advent of the English sparrow—a bird which is not a pronounced insect eater—many of the birds that previously nested in the cities have been driven to more remote districts.

City trees unhealthy.

The city tree under the most favorable conditions must keep up a continual fight for existence. Impure, smoke-laden atmosphere; poorly watered and badly ventilated root system; the careless, thoughtless mutilation by teamsters and passers-by, all tend to weaken it. If in this weakened condition it becomes the subject of attack, it is poorly fitted to withstand the burden and, unless assisted, stands a poor show to win out in its fight for existence.

INSECT CONTROL DIFFICULT IN CITIES.

Individual work of householders impracticable.

The application of insecticidal measures is a difficult task under most city conditions, especially so if the various householders attempt the operation individually. It is usually the case that a few trees only are located in each yard, and frequently these trees are tall, thus requiring a strong, expensive spraying apparatus for treating them properly. Besides the sprayer the service of two men is required, at least one of whom should have a knowledge of machinery and the preparation of insecticides to insure best results. It is only in the case of large lawns that it would be practicable for private individuals to own and operate spraying outfits.

However, in a few instances, designated in the description of the various shade tree pests following, it is possible for the householder to furnish effective assistance, and to do so with small expenditure of time and money.

A municipal tree-treating department desirable.

The more desirable and practicable arrangement is for the city to support a tree spraying department, operated by competent, experienced men, whose business it is to look after the public trees and who are prepared to do spraying on private grounds for a reasonable charge. Such departments are already in existence or are under way of organization in some of our principal cities, the department at Cleveland being the most complete in this state.

CORRECT PLANTING THE FIRST STEP TOWARD INSECT CONTROL.

From the standpoint of the future control of insect pests, two things should be considered in the planting of a shade tree; the species of tree and the location of planting.

Some trees more susceptible to insect attack than others.

All kinds of shade trees are not equally susceptible to insect attack, some being almost immune, others so highly susceptible to attack from one or two species that it is impossible to grow them, while still others are the prey of a whole host of depredators.

Dr. E. P. Felt, in his most excellent work on "The Insects Affecting Park and Woodland Trees," has tabulated the more common trees of New York state with relation to their liability to insect attack. As Ohio conditions do not vary to any great extent from those found in New York state, the classification arranged for New York holds good in the main here. Dr. Felt's rating, with a few alterations that will be designated later, is as follows: "The figure 3 has been placed opposite trees which are practically immune from insect injury; 2.5 indicates some damage. Trees having one somewhat serious enemy are rated at 2 and those having at least one notorious insect pest at 1.5. Greater likelihood of injuries is indicated by 1 and still more by .5. The species are arranged according to the comparative injury as follows:

Tulip tree 3	Catalpa.....2
*Tree of heaven..... 3	European linden.....1.5
Gingko.....3	American linden 1.5
Red oak.....2.5	Horse chestnut.....1.5
Scarlet oak.....2.5	Soft or silver maple..... 1.5
Oriental plane tree.....2.5	American elm.....1.5
American plane tree.....2.5	*Hackberry..... 1.5
Sycamore maple.....2	European elm.....1
Sugar maple..... 2	Scotch elm.....1
White oak..... 2	Cottonwood. 5
Burr oak.....2	Balm of Gilead..... .5
Red maple..2	Yellow locust..... .5
Honey locust.....2	

*Those that are starred have been seen only in parks or in such small numbers that the rating can be regarded as provisional only."

The above arrangement differs from that of Dr. Felt's list in the position of catalpa, rated by him as 3 and here rated as 2 on account of it's being subject to attack from the catalpa sphinx in the southern sections of the state and rather generally to the action of the catalpa diplosis (or a closely allied species) working in the tender, growing tips. Also the hackberry and elm are rated .5 higher because of the fact that the elm leaf-beetle is not well established in this state.

Plant mixed varieties.

Another general principle of correct planting, as brought out by Dr. Felt, is the undesirability of planting clumps or rows of a single species. It may easily be seen that an insect on the hunt for its favorite food plant is much more likely to locate a collection of trees than single individuals scattered here and there. Further, that a pest is more easily disseminated when once it becomes established on one of a number of trees of the same variety growing close together, than if the trees were at least alternated with other kinds.

Avoid poor environment at planting time.

It is an admitted fact that insects prefer the weaker to the stronger plant, and when we consider how much more easily a healthy, vigorous tree withstands insect attack than does its weaker neighbor, it is self-evident that, if for no reason other than the future control of insects, we should attempt to grow strong trees. Much can be accomplished toward this end by not planting in unfavorable immediate surroundings, such as over or near a gas main, thus running the risk of having the tree poisoned by escaping gas; nor directly under high-tension electric wires, the injurious burning effects of which are well known; nor too near the street, where the trunks are subject to injury; nor in soil deficient in plant food; nor in a half dozen or more additional situations that might be named.

Plant to make insect warfare possible.

Tall growing species subject to insect attack should not be planted close beside buildings, thus making it impossible to spray them properly without covering the side of the building with the spraying mixture. This is one of the great difficulties experienced by a city spraying department. Householders object seriously—and justly too—to the disagreeable mixtures. To illustrate the necessity for exercising this precaution take, for instance, the applying of the lime-sulfur wash, a mixture used quite extensively as a scale destroyer. This mixture when sprayed upon a painted surface combines chemically with the paint, causing some shades to discolor. It is absolutely impossible to spray a tree located beside a building without some of the mixture being misplaced.

COMMONLY INJURIOUS SPECIES.

It is the author's intention in his treatment of the individual shade tree pests to deal with each species as briefly as possible, but at the same time to afford a working knowledge for operations against it. To this end the description of the various insects will be confined to pointing out the characteristics most useful in differentiation, and only such phases of their life histories will be dwelt upon as bear directly upon our understanding of the methods of control suggested. No attempt is made to list all of the insects that may be found injuring ornamentals or forest plantings within the borders of the state, but only those species are considered which are at present doing damage or those that may likely be introduced within the near future. For more complete information, no better source may be found than Memoir 8, New York State Museum, entitled "Insects Affecting Park and Woodland Trees" by Dr. E. P. Felt.

The observations and practical spraying experience herein recorded, in addition to the information compiled from the writings of others, are mainly the result of work done by the Ohio Experiment Station, in co-operation with the Department of Forestry of the City of Cleveland.

SCALE INSECTS.

Scale insects are among the most formidable of the pests from which the shade trees must be protected. On account of small size and protective coloration they frequently escape detection by the untrained eye until they have secured such a strong foothold that the host is permanently injured. Further, in addition to the advantage they possess by reason of the insidious nature of their attack, some are extremely resistant to remedial measures, among these being some of our most common species, such as oyster shell bark-louse, terrapin scale of the maple, etc.

The majority of the species remain fixed after the scale covering is formed. The spreading is effected by the young as they crawl about seeking a suitable place to begin feeding; as they are carried short distances by spider webs or winds; or possibly longer distances upon the feet and feathers of birds. This motile period in the history is of short duration, usually not longer than two or three days.

Insects of this order obtain their food by inserting their sharp, hair-like beaks into the tissues of the plant and drawing out the sap, hence applications of poisons are ineffective, and for all practical purposes it may be said that control methods are confined to spraying with contact insecticides during one or both of two seasons, the latter depending upon the species. Some scales are more easily destroyed by the action of a strong spray, used during the winter months, while others are susceptible to treatment with a weak spray applied during the summer months when the brood of young is appearing. The last named method, however, is useful only when the entire brood of young appear within a few days, and when the host is foliated sparsely enough to permit the spray to reach all parts of the plant.

The oyster-shell bark louse, Lepidosaphes ulmi. (Plate 1, Figs. 1, 2 and 3.)

In appearance this scale is dark brown in color, shaped like an oyster shell, and is about one-eighth inch in length. The winter is passed in the egg stage under the protection of the covering scale, the large quantity of whitish eggs being quite easily detected if the covering is removed. The eggs hatch during the latter part of May or early June, at which time the tiny, yellowish, mite-like scale insects may be located by the unaided eye, as they crawl about seeking a suitable place to begin feeding.

A number of plants are quite susceptible to this scale, the most common for Ohio being Carolina and Lombardy poplar, willow, horse chestnut, ash, sassafras, and red-twigged dogwood. The poplars are undoubtedly the most susceptible of all, and so injurious in fact is this scale to these trees that the authorities in Cleveland have stopped the planting of them, and wherever practicable are replacing growing trees with more desirable kinds.

Spraying during the early spring with the lime-sulfur wash, or during the hatching period with kerosene emulsion or whale oil soap solution, is the remedy usually employed against this pest. However, for extensive spraying operations, the two latter materials are hardly practicable, as in order to be effective they must be applied during the interval between the hatching of the scale insect and the completion of the first scale covering. This allows a few days only and therefore is prohibitive of work on a large scale.

The lime-sulphur wash is undoubtedly the best of the control methods to be used against this scale, but in the author's experience it has proven somewhat of a disappointment. From observations made upon hundreds of trees and shrubs, sprayed with a mixture made by experienced men and applied thoroughly, it is apparent that only when conditions are the most favorable are the results following its use satisfactory. A slight dampness, such as light fog, at the time of application; a somewhat weakened spraying mixture; an extra case of infection where several scales are piled upon one another; a temperature below 32 degrees; any of these unfavorable conditions is sufficient to give poor results.

In spraying trees that are deeply incrusted with the scale, the mixture cannot be forced to penetrate underneath the outer layers and frequently many escape, to multiply the ensuing year.

Sassafras and soft maple, both well infested with this species, were carefully sprayed under favorable conditions during the spring of 1907, with scalecide and limoid. This scalecide was used in a 5 percent solution, and the limoid was prepared after the following formula: Limoid, 30 lbs., kerosene, 7½ gal., water to make 50 gallons. In every instance the scale increased abundantly during the ensuing season, indicating that little benefit had resulted from the treatment.

Because of the power often possessed to withstand the action of the most practicable of the stronger scale insecticides as a winter treatment, and of the the impossibility of doing extensive work during the summer period, the writer is almost ready to place the oyster shell on a par for destructiveness with the San Jose species, when it occurs under city conditions.

The San Jose Scale, Aspidiotus perniciosus Comst.

This species is almost well enough distributed and well enough known to render a description unnecessary. However, it may be stated briefly that the individual scales are very flatly conelike, with a whitish nipple at the apex; the remainder of the scale is gray or blackish and the whole is about the size of a pinhead. When occurring in large numbers on a branch it gives it a gray ashy, flaky appearance. Additional distinguishing features are that when a tree becomes badly infested, pressure upon the limbs with a knife blade or similar flat instrument causes a yellowish oily liquid to appear. Following infestation the tree assumes a sickly appearance and ultimately dies if uncared for. The length of the period between infestation and fatality depends of course upon the natural hardiness and the resources of the host. Some trees and shrubs may withstand the burden of attack a considerable number of years while others, less hardy, as the peach, may succumb in as few as three years. According to Dr. W. E. Britton, State Entomologist of Connecticut, a little over one-third of the trees, shrubs, and vines grown for fruit and ornamental purposes are subject to serious attack from this species, while an additional third are occasionally or rarely infested. The more common of the plants suffering seriously are as follows: juneberry, hawthorn, privet, poplar, Prunus spp., currant, apple, rose, willow, ash, lilac, osage orange and elm.

The scale is well distributed throughout the State, there being very few counties only from which it is not reported. It is rapidly gaining headway each year, notably in the cities and towns, where as yet comparatively little systematic work has been attempted to hold it in check.

In many parts of the country and particularly in the orcharding districts annual spraying is being performed. Where such is the case and thorough work is done the advance of the pest is being checked and the damage reduced to a scarcely perceptible amount.

A winter application of the lime-sulfur wash is the safest, most effective and cheapest remedy for this pest. However, by way of modification of the statement concerning the cost of the spray, it should be said that this holds true only where the wash may be purchased at a rate affording no more than a reasonable profit to the maker, or where the area to be treated is sufficiently large to warrant the expense of setting up the boiling plant. Where it is impossible to purchase the wash or where it is impracticable to arrange a private plant for preparing it, then some of the commercial insecticides may be resorted to. Among washes of this class

the Experiment Station has tried during the past two or three years the one known as Scalecide has given the best results. This material is a patent so-called soluble oil, in other words an oil emulsified so that when water is added the two combine, resulting in a milk-white, oily spray. This material is not excessively expensive and serves most excellently the purposes of the householder who has a small area to be treated, and who has not access to the public sprayer or cannot hire the work done.

The Scurfy Bark Louse, Chionaspis furfura Fitch.

This insect appears in the adult stage as flat white specks upon the bark or fruit of the host. The female is about 1-10 inch in diameter and shaped after the outline of a pear, while the male is about one-third as large and more elongated. (Plate 1, Figs. 4 and 5.) With both sexes there is a yellow pellicle at the tip end of the scale. The winter is passed in the egg stage under the protecting mother scale, hatching occurring during the latter part of May or in early June.

Some closely allied species occur in great numbers at times on park trees and shrubs, but for the most part they have life histories that are similar to the common species and in general the same remedies will apply. The red-twig dogwood, willows and some of the rosaceae are particularly subject to such infestation.

The lime-sulfur wash applied during the winter is effective, as are also contact sprays applied at hatching time. However the same difficulty arises here that is encountered in connection with summer applications against the oyster shell bark louse, *i. e.*: the brood appears *en masse* and the time for effective work is as a result very brief.

The Putnam Scale, Aspidiotus ancylus Putnam.

On account of similarity in general form this species is frequently mistaken for the San Jose Scale, especially when the infestation is slight and the scales immature. The superficial distinguishing features however are as follows: the scale is slightly darker in coloration; the nipple reddish; the spread less rapid; the injury less severe, and lastly the young exhibit a stronger tendency to settle about the mother, resulting in a somewhat irregular infestation.

This insect occurs more commonly in the towns than in the country, and the trees most generally attacked are hard maple and linden. The maples in the parks and upon the streets in Cleveland suffer severely from this pest.

The lime-sulfur is effective against this pest. Applications of limoid and scalecide gave fair returns.

The Rose Scale.
Aulacaspis rosae Bouche

This species resembles the scurfy bark louse, though the general appearance of the infestation as a rule is of a whiter, fluffier nature. (Plate 2, Fig. 1.) The life history is practically the same as that of the scurfy scale, and the winter applications of the lime-sulfur wash are effective. Scalecide in 5 percent solution was not successful.

Roses, blackberries and raspberries are most commonly attacked. *Rosa rugosa* is more severely attacked than other roses, but even with this variety, the writer has observed very few instances where the plants were killed.

The Elm Scurfy Scale.
Chionaspis Americana Johns.

This species occurs upon the elms and the lindens. It resembles very closely the scurfy bark louse, in fact it is quite likely that for many years it was confused with this insect. The life history is the same. In the writer's observation, however, the elm scurfy scale is not so evenly distributed over the host plant as is the scurfy, the lower side of the branches being more subject to infestation.

Lindens moderately infested with this scale were sprayed with lime-sulfur, April, 1907. Observations made during the ensuing season indicated that the results of the application were all that could be desired. In the vicinity of the lime-sulfur sprayed trees, other lindens were sprayed with 5 percent scalecide. Little good seemed to result from this treatment, as the scale developed in abundant quantities during the following season.

Contact sprays applied at hatching time are effective against this species, but as has been indicated in the case of other scales with a similar life history, they are hardly practicable.

The Cottony Maple Scale,
Pulvinaria innumerabilis Rathv.

During the early summer months this scale is easily detected by the presence of a white, cottony mass which the insect exudes from beneath the covering scale. (Plate 2, Fig. 2.) Within this mass may be found the eggs, the number varying from a few hundred to two thousand. Hatching occurs during the early summer and the young migrate to the leaves or to the tender young growth, where they settle and begin feeding upon the sap of the tree. Meanwhile a thin scale covering forms over each individual, which with the growth of the insect enlarges and in time turns brown. Before the leaves fall most of the insects migrate to the branches and trunk, where they settle preparatory to passing the winter in their partially grown condition. With the coming of spring maturity is soon reached and the cottony mass already described appears.

The species prefers soft maple, though a number of other trees are subject to slight attack, among the more common being hard maple, honey locust, elm and grapevine.

Two species very closely resembling the one just described attack the hard maple: the maple leaf scale, *Pulvinaria acericola* Walsh and Riley, and the maple *Phenacoccus*, *Phenacoccus acericola* King. The former is found upon the leaves and the latter upon either the leaves or branches.

Natural parasites play an important part in the economy of this insect, in most seasons being sufficiently numerous to prevent serious damage. However, for some reason the natural enemies are not always successful in developing and considerable harm is done by the scale. When the insect becomes sufficiently troublesome to require attention, winter spraying with kerosene emulsion, containing from 12½ to 25 percent kerosene, is the remedy most commonly recommended.

The tests of the value of different spraying materials that have been performed by this department against the insect under consideration have been conducted upon trees only slightly infested, so that the results were not as conclusive as they might have been. A clump of soft maples was divided into plots and sprayed during the latter part of March and early in April, 1907. The following were the mixtures applied: Scalecide, 5 percent solution; Scalecide, 3 percent solution; Limoid, 15 percent kerosene; Limoid, 7½ percent kerosene; Kerosene emulsion, 12½ percent kerosene.

The kerosene-limoid, containing 15 percent kerosene, killed practically all of the scales; the kerosene emulsion sprayed plot came next in order of cleanness and the value of the remaining materials is indicated in the following order: Kerosene-limoid, 7½ percent, scalecide 5 percent and scalecide 3 percent. The weaker solution of scalecide was of little value.

In another section the merits of the lime-sulfur wash and of 17 percent limoid were compared, resulting favorably toward the limoid and in practical failure for the lime-sulfur solution.

The Maple Terrapin or Black Banded Scale, Eulecanium nigrofasciatum Perg.

This insect is sharply hemispherical in form, the adult female is about one-sixteenth of an inch in diameter and the color, though variable, is of a general reddish tone with a more or less distinct blackish band near the border. One of the most distinctive characteristics, however, is the peculiar sickening odor that is especially noticeable when the well grown scales are crushed.

Soft and hard maples suffer most commonly from this pest.

The winter is passed in a partially grown condition, maturity being reached and egg development completed early in June. Usually about the middle of June the young appear.

In the author's experience winter applications of the stronger insecticides commonly used against scale insects have proved unsuccessful in furnishing a control, in fact the insects seemed to be little harmed by the applications. It may be found, however, that kerosene emulsion containing 20 to 22 percent kerosene will bring about the desired results. This, however, cannot be given as an authoritative statement. The emulsion used in the experiments against the pest was only 14 percent kerosene, as it was not deemed safe to use a stronger mixture. Subsequent trials have demonstrated, however, that a hard maple will stand, during the dormant period, applications of an emulsion containing 20 percent kerosene and in some instances will recover from the effect of applications containing 40 percent kerosene. See Plate 4, Fig 2. The hard maple is more liable to injury from the application of strong emulsion than is the soft maple.

The Elm Bark Louse, Gossyparia spuria Modeer.

The adult females of this insect are the most conspicious forms. (Plate 3, Fig. 2.) The following description is taken from Memoir 8, N. Y. State Museum. "They may be seen clustered along the under side of the smaller limbs, usually beside a crack or crevice in the bark, and presenting a general resemblance to a growth of lichens. The full grown viviparous females are about 1-10 inch long just before giving birth to their young, oval in outline and with slightly pointed extremities. Each is surrounded with a white, woolly secretion, which also extends partly over the insect and thus renders its segmentation more apparent." The females become full grown in early spring and the young appear during the month of June.

This insect occurs upon the elms in Marietta and according to Burgess in Columbus is not known to occur in any other portions of the state. According to Dr. Felt it is present in the following parts of the Union: Vermont, Massachusetts, District of Columbia, Michigan, Nevada, Colorado and New York.

In June, 1906, the writer made a careful study of the condition of the city of Marietta. The insect was found to occur in various parts of the city, the vicinity of the chair factory being seemingly the center of infestation. It is not known definitely when it was first introduced, nor is there any plausible theory as to how the introduction was made. The trees were not in a serious condition,

though some of the limbs were dying. The majority of the scales were upon the lower limbs, though many specimens were found as high as 46 feet from the ground.

What is known as the bitter elm is most subject to attack. The water elm is rarely attacked and, if so, very slightly, even when growing beside infested specimens of the former species.

The progress of the insect will be watched with considerable interest as it is considered a serious pest in some of the localities before mentioned.

June 28, 1906, while the young scales were emerging, an application of kerosene emulsion containing 7 percent kerosene was made to a small elm badly infested. The tree was very thoroughly sprayed, special care being taken to follow out the under side of the limbs. The treatment was successful in destroying the young insects already emerged, but did not seem to affect the females nor the young beneath the mother scale, as the young were noticed emerging in considerable quantity an hour after the conclusion of the treatment.

Prof. R. H. Pettit, of the Michigan Agricultural College, reports success from the use of the lime-sulfur wash upon the elms located upon the college grounds. It is quite likely that this is the most practicable and satisfactory spray to be used.

Tulip Tree Lecanium, Eulecanium tulipiferae Cook.

The tulip tree lecanium is one of the scales quite frequently received by the entomological department, not that it is especially common, but because it is easily detected. In cases of severe infestation the branches on which it occurs appear irregularly knotted.

Occasionally, fatal results are reported to follow its attack, but in the writer's experience he has never seen a tree killed or severely injured by it. However, the large fleshy scales surely consume considerable of the tree's sap and thus harm it to a certain extent. Applications of control methods are in no wise misplaced. As the scales are so large and so easily detected, probably removing them with a stiff wire brush is the most practicable remedy.

The Pine Leaf Scale, Chionaspis pinifolae Fitch.

This is a small, elongated, snow-white scale, at the narrow end of which is attached a small yellow pellicle. It is found attached to the leaves of the pine. (Plate 3, Fig. 1.)

The winter is passed in the egg stage. Two broods occur annually, one in early summer and the other during the fall.

During the spring of 1903 the pines on the Experiment Station grounds were badly infested by this insect, some of the trees being

in a dying condition. A weak kerosene emulsion was applied at the time the first brood was emerging and a very dilute solution of whale oil soap at the time the smaller fall brood appeared. As a result the trees were almost completely cleared of the pest, and additional treatments have not been found necessary thus far. However, the scale is again obtaining a rather strong foothold and will soon need attention. The insect is illustrated, natural size, in Plate 3, Fig. 1. There is also shown in the illustration an adult of the twice-stabded ladybird *Chilocorus bivulnerus* Muls., a natural enemy of the scale which does considerable towards holding it in check.

The Golden Oak Scale, Asterolecanium variolosum Ratz. This scale was recorded at Mentor by Newell in 1900 and was also received from Glendale in 1907. An infested tree stood in a lawn adjoining Edgewater Park, Cleveland, in 1906, and on it, July 19, the young were appearing in immense quantities. The scale is easily determined on account of a yellowish-green golden color and because it causes a slight abnormal growth upon the twig, thus presenting the appearance of being partially imbedded in the bark. Although alive, the trees infested were not healthy, the bark being very rough and uneven and seemingly only partially able to fulfill its duties.

Kerosene emulsion is an effective remedy when applied during the hatching period.

The Fine Bark Aphid, Chermes pinicorticis Fitch. Though not a scale, this insect may logically be considered here, as it's appearance is much the same as that of some of the scales and the control methods are similar. The adults are illustrated in Plate 3, Fig. 3, where they may be seen as collected in thick, white, floculent masses upon the base of the pines. The pest has been noticed for the past two seasons upon certain trees in the Experiment Station gardens, and the writer has observed it in lesser quantities than those shown in the illustration upon pines in the Cleveland parks.

The foliage of the trees that are worst infested upon the Experiment Station grounds is beginning to loose color, indicating the vitality of the trees is becoming weakened.

The pest is subject to the action of contact sprays, according to Dr. E. B. Southwick, Entomologist of the New York parks, the stiff sprays being effectual.

THE LEAF EATING INSECTS.

The White Marked Tussock Moth, Hemerocampa leucostigma Sm. & Abb.

This insect undoubtedly heads the list of leaf-eating pests found in Ohio. It is easily distinguished during all stages of it's life history. See Plate 5. Two broods occur each season, the young larvae of the first appearing soon after the leaves are well out upon the majority of the shade trees. The winter is passed in the egg stage.

The eggs are deposited upon the discarded cocoon of the female moth, in a white frothy mass from ½ to 1 inch in length and varies from 200 to 400 in number. The frothy aspect results from the brittle material that binds the mass together.

The larva upon first hatching is a hairy caterpillar about 1/6 inch in length and, while young, has the power of spinning a silken thread with which it lowers itself if the tree is jarred or suddenly shaken by wind. Currents of air, swinging it, may deposit it upon the nearby trees and this is one of the means by which the spread of the insect is effected.

The newly hatched larva feeds for a time upon the epidermis of the lower side of the leaf but as it grows older and stronger more of the leaf is eaten until by the time it is full grown all but the midrib and larger veins are devoured.

The grown larva is one of the most beautiful caterpillars occuring in Ohio. The head is coral red; extending longitudinally along the back is a broken black line bordered by narrower lines of yellow. The yellow bands are bordered by broader ones of drab. Below, the caterpillar is yellow. Projecting forward like horns just above the head are two black tufts of hair ⅓ or more the length of the body, and extending from the opposite end is a single tuft of the same texture, though not quite so long. On the dorsal side of the 4th, 5th, 6th and 7th segments are compact tussocks of pure white hair and on account of this the insect is called the Tussock Moth. The larval stage is of a little over a month's duration. Upon the completion of larval growth the caterpillars become abnormally active, crawling about, seeking a suitable place to pupate. During their wanderings they may travel considerable distances and it is mainly at this time that the advance from tree to tree is effected.

After a satisfactory place has been found in which to pupate, the larva constructs for itself a cocoon, mainly from the hairs of its own body. About two weeks are spent in the pupal stage at the the termination of which the adults appear. The adult female is

wingless and never leaves her cocoon until her eggs are deposited as previously described. With the completion of oviposition she dies and usually falls to the ground.

The male has feathery antennae, hairy legs and a wing expanse of nearly an inch. The wings and body are rather definitely marked with varying shades of gray.

For several seasons previous to that of 1907 the insect appeared to be gradually increasing in numbers and in destructiveness in the city of Cleveland. During the early part of the season of 1907, the first brood, which was an unusually large one, was beset by an army of parasites, resulting in a very small second brood of larvae.

A consignment of larvae and pupae placed in the breeding cages gave forth a large quantity of Hymenopterous and Dipterous parasites. In addition to the parasites just named, Heteropterous nymphs, the adult form of which we were unable to obtain, were observed clustered about the cocoons with their beaks inserted into the chrysalid or larva, as the case might be, that was contained therein.

The principal hosts for this species in Ohio are lindens, horse chestnuts and elms.

During the season of 1907, three methods of combatting this insect were given trial. The first consisted in clearing the egg-masses from small elms on Euclid Ave. See Plate 8, Fig. 2. The collecting was done during the spring months. The trees were in a small park removed some little distance from other trees. As a result of the treatment they were unaffected by the insect during the entire summer following. However, as before stated, the trees were small, and the work of clearing them could be very thoroughly done. This is one of the standard methods to be used against the pest.

When the infested trees are very tall, thus rendering collecting impossible, dampening the masses with creosote is sometimes substituted. The operation is performed with a sponge dipped in creosote tied to the end of a long pole. Where trees that have been cleared of the egg-masses are situated in the vicinity of other plantings it is well to supplement the collecting process by banding the trunks of the trees with mechanical barriers, such as rings of cotton batting or bands of sticky material, such as Thum's tree tanglefoot.

The second method given trial during the summer of 1907 was spraying lindens with kerosene emulsion containing 5 percent kerosene and with arsenate of lead, 3 pounds to 50 gallons of water; supplementing the treatment in each case with bands of tanglefoot fly-

paper. Ses Plate 7, Fig. 1. At the time of the treatment, the first brood of larva was beginning to give evidence of its presence by its work upon the leaves.

Both sprays killed the feeding larvae and the trees were practically free from the insect during the entire season, whereas, their untreated neighbors were partly defoliated. The sticky materials upon the bands was replenished once during the summer with a coating of Thum's tree tanglefoot.

The third measure looking toward control that was tried experimentally, was the application of strong kerosene emulsion at the time the first brood of larvae was transforming to the pupal stage. Horse chestnuts that had been defoliated by the first brood were heavily sprayed with strong kerosene emulsion July 20. The trees were located in front of 2236 84th St. SE. Directly adjoining these trees were other horse chestnuts that were left unsprayed for comparison. The comparison however was not a fair one as the untreated trees had in no wise suffered as severely as had the others. An idea of the appearance of the tree at that time of treatment may be had from Plate 6, Fig. 1.

August 30, the tree was again photographed as shown in Plate 6, Fig. 2. At the later date scarcely a single larva could be seen upon the treated trees and a small crop of new foliage had grown meantime; while enough larvae had escaped the parasites on the untreated trees to do considerable harm. A comparison between the treated and untreated trees may be drawn from Plate 7, Fig. 2. It may also be seen where some larvae from the untreated tree had gained access by means of the interlocking branches to the treated tree, and had destroyed a portion of the second crop of foliage.

As a general specific measure to be used in combatting this pest, the author believes there is nothing more effective and practical than collecting or treating the egg masses during the winter months and keeping the trees banded with tanglefoot from the middle of June until the first killing frost. This measure is escially commendable for individual operations as the cost would not be excessive to hire nimble workmen to climb the trees and destroy the egg-masses. It would only remain to keep the bands in good working order. If the work of destroying the cocoons is thoroughly done and the trees so treated are not close enough to neighboring trees so that the young caterpillars are able to span the distance with their webs, there is no reason why careful banding alone should not keep the trees free of this pest.

If impossible to collect the egg masses, spraying with arsenicals is next in order but it too should be supplemented with banding and the mixture should be applied while the larvae are young.

The Forest Tent Caterpillar, Malacosoma disstria Hubn.

During the last half century there have been occasional severe outbreaks of this insect in widely separated sections of the United States, the hard maple being the principal sufferer in the north.

The eggs are deposited in late summer, usually upon the lower branches of the tree, though they sometimes may be found upon the topmost twigs. They are placed in belts of about 150 each surrounding small twigs. After the egg is deposited, the larva develops within the egg-shell, but does not break through until the following spring, about the time the leaves are appearing. As the larvae feed and develop, they do not spin a sheltering web as do some of the other leaf-feeding caterpillars, but, as they pass up and down the limbs of the tree, they spin a silken thread behind them, which after many passages becomes a silken path. When not feeding upon the leaves they rest in clusters upon the limbs and trunk of the tree. They also take this position to shed their skins.

The full grown caterpillar is about two inches in length and is characteristically marked with a blue head and a row of diamond shaped spots down the middle of the back.

The cocoons are spun in any sheltered position, such as among crumpled leaves on or under the tree, in crevices of the bark and of fence-posts, etc. They are composed of the hairs from the insect's body, silken threads, and a liquid which the caterpillar ejects, the latter giving the mass a yellow, powdery appearance.

The adult is a brown moth, bearing a darker colored band across each fore-wing, almost parallel to the outer border. They fly mostly at night.

Concerning remedial measures, as with the tussock moth, much good may be accomplished by collecting and destroying the egg-masses during the winter months. However, this method is not as fully applicable in the present instance as the egg-masses are not so conspicuous. Probably the best method of control is spraying with arsenicals at the time the larvae appear. As with the tussock moth it will probably be of advantage to band to prevent reinfestation.

The Fall Web Worm, Hyphantria textor Harris.

The distinguishing characteristic of this insect is seen in the large unsightly webs occurring most commonly upon wild cherry during the late summer. Upon critical examination, it is seen that the webs contain a quantity of hairy larvae which feed upon the more or less browned leaves of the twigs enclosed. This discoloration results from the insect's eating the

softer portions of the leaves causing the remainder to die. Occasionally, as the larvae approach maturity, the food supply is exhausted within the web and they wander to adjoining twigs. The pupal stage is passed in a thin cocoon, usually located in trash on the surface of the ground or just below the surface.

Both sexes are winged moths, white, or white dotted with black. The eggs are deposited upon the leaves.

Because of the conspicuous web, one of the common methods used in combatting this pest is clipping the twigs from the tree to which the masses are attached and destroying them. This, however, involves a loss of a part of the tree and for this reason it is preferable, where possible, to spray with arsenicals when the young caterpillars are known to be emerging. This occurs during the month of June. See Plate 9, Fig. 2.

The Bag or Basket Worm, Thyridopteryx ephemeraeformis Haworth.

Insects of the class to which the one under present consideration belongs, derive their popular name from the curious bag or basket which is constructed during the larval stage. Soon after the larva is hatched it contructs for itself a silken sack, smooth inside, while to the outside are attached portions of bark, leaf tissue, leaf petioles, etc. From the open end of the bag the larva protrudes its head and fore legs, and thus walks about at will, dragging its home with it. To one unaccustomed to the sight it is indeed a surprise when the curious semi-shapely bundle of trash that has attracted his attention, suddenly develops life and moves away.

As the enclosed larva grows, the bag is enlarged from time to time by additions to the open end. Upon reaching maturity the larva binds its case to a limb and pupates. At the end of the pupal stage the males emerge and fly about, while the females, being wingless, oviposit within their old cases and afterwards wriggle out to fall upon the ground and die.

The winter is passed in the egg stage.

A number of bag-constructing insects occur in Ohio: one, a small species, and quite common, covers its bag with portions of grass stems, and the empty cases may be found attached to fence posts, etc. The one under discussion is a comparatively large species, the completed bag varying in length from 1½ to 2 inches. It was observed doing considerable damage to shade trees during the past season in the central and south-western portions of the state.

A large number of trees and shrubs serve as food plants, the ones most commonly found during the past season being sycamore, horse chestnut, hard maple and willow. The most severe case of attack coming to the author's attention was upon hard maples in Cincinnati. See Plate 11, Fig 2.

Probably the simplest and most effective of the methods to be used in combatting this pest is the collecting of the conspicuous bags during the winter, thus destroying the eggs; followed by the application of mechanical barriers placed around the trunk of the tree, to prevent it from being reinfested by larvae wandering from other sources.

Another remedy applicable during the summer season when the larvae are feeding is spraying with arsenicals. See Plate, 10 Figs. 1 and 2, and Plate 11, Fig. 1.

The Brown Tail Moth, Euproctis chrysorrhaea Linn. This species occurs only in the New England States at present, but unless something unforeseen happens it will be only a matter of time until it spreads to this state. The following description is taken largely from Memoir 8, New York State Museum, and is herewith given that the pest may be recognized and prompt measures be taken to stamp it out when it reaches our borders.

The insect has two features peculiar to it which render its separation from other insects comparatively easy. The first is the presence of a tuft of brown hair on the tips of the abdomens of the moths of both sexes, and the second is the position in which the webs are spun, namely, upon the tips of the branches.

The female moth is white in color with the exception of the brown marking already described, and measures 1¾ inches across her spread wings. The male is smaller, having a wing expanse of 1¼ inches, and the general white of the wings is broken with a few black spots. The brown tuft on the abdomen is smaller and darker in color than that of the female.

The moths fly during July, and during this season the eggs are deposited in masses on the under sides of the leaves. From 200 to 300 are clustered together and are then covered with the brown hairs from the tip of the abdomen of the female.

Upon hatching, the young feed gregariously upon the surface of the leaf, spinning a covering web as they go. They soon begin the preparation of their winter nest by drawing a few leaves together and lining them with silk, and binding the whole tightly to the twigs. The winter is passed in the immature larval condition within the protection of the soil.

"Early in the spring the caterpillars emerge and, if the leaves have not started, begin feeding upon the swelling buds. During the spring they continue their work, completely stripping the tree in cases of severe attack. One brood occurs annually.

"When full grown the caterpillars are 1½ inches long. They are dark brown with a sprinkling of orange. Long, fine, reddish hairs cover the body, and a row of conspicuous white hairs runs along each side. Like the caterpillars of the tussock and gypsy moths, they bear bright red eversible tubercles on the top of the sixth and seventh abdominal segments."*

Besides doing great injury to the trees in badly infested districts, the caterpillars are equally obnoxious because of the poisoning effect the spines from the hairs of their bodies have upon human flesh. Contact with the insect's body, with cast skins as they are blown about, with the cocoons or with clothing in which the spines have gained access, may cause the characteristic irritating eruptions.

The cocoons are placed upon the leaves or in some sheltered position. They are lightly covered with the brown hairs from the tip of the female abdomen.

As to food plants, according to Dr. Felt, the insect feeds upon such fruit trees as the pear, apple, plum, and cherry, and upon the following forest trees: oak, maple and elm.

The remedial measures are comparatively simple, consisting of the collecting and destroying of the conspicuous winter nests. Spraying with arsenicals is also to be relied upon, but the former is preferable because of the smaller expense involved.

The Gypsy Moth, Porthetria dispar Linn.

This, as with the preceding insect, is one that Ohioans may happily say does not occur within the borders of the state. It was introduced into Medford, Mass., in 1868 or 1869, but did not develop in excessive numbers until 1889, when the attacks became very severe in the locality of its introduction.

At that time the state of Massachusetts began making annual appropriations for the purpose of combatting the pest and during the nine years following over $1,000,000 was expended. During that time the insect spread slowly, and since 1899, when the appropriations were discontinued, more rapidly, so that at the present time a considerable area of Massachusetts is infested, and the infestation has spread to at least one of the neighboring states (Rhode Island.)

"The eggs of this insect are deposited usually in round or oval patches on a piece of bark and then covered with the buff-colored scales from the underside of the female's abdomen. A completed egg-mass looks very much like a small piece of sponge. The egg-mass may be found on stones, in tin cans, and in fact on almost any fixed object near at hand, preferably on the under surface, particu-

*Bul. 108, Maine Agricultural Experiment Station.

larly of limbs and fence rails. The nearly globular, pale yellowish or salmon-colored eggs are about one-twentieth of an inch in diameter, and there are usually 400 to 500 eggs in a cluster, though occasionally 1000 may be found in an egg mass.

"The young caterpillar is slightly over one-tenth of an inch long just after it emerges from the egg. It has a black head, the body is brownish yellow and well clothed with long hairs. There is a prominent hairy tubercle on either side of the segment next the head; this gives the caterpillar a peculiar broad-headed appearance, especially in its early stages. The markings become plainer as it increases in size, and when full grown it is from 2 to 2½ inches long. This caterpillar has a double row of conspicuous warts or tubercles down its back, the eight anterior blue, the 12 remaining red, not counting the four blue ones just behind the head. Similar tubercles also occur on the sides.

"The somewhat conical, dark brown pupa ranges from ¾ to 1½ inches long. It is usually found lying among a few threads and securely attached to them by its terminal spine.

"The male and female moths differ markedly. The former, a slender, olive brown, black-marked creature with feather-like antennae and having a wing spread of about 1½ inches, may be seen flying in the late afternoon and early evening in considerable numbers. The female is much heavier and lighter colored. She has a wing spread of about 2 inches and is a white or buff white color with more or less distinct black markings. The abdomen is tipped with buff. The female moth does not fly though she apparently has well developed wings.

"The winter is passed in the egg-mass, which is remarkably resistant to atmospheric and other agencies. Experiments have shown that even when the egg clusters were broken up and freely exposed to the elements, the eggs were apparently not harmed, and a normal proportion of the caterpillars appeared at the usual time, which, in the vicinity of Boston, is from the last of April until the middle of June. The feeding period extends from the first of May to about the middle of July, a caterpillar requiring from about 9 to 11 weeks to complete its growth and enter the pupal stage. The young caterpillars remain on the egg clusters from one to five or more days and then commence feeding on the leaf hairs. Soon they eat out small holes in the leaves and, after the third or fourth molt, about as many feed on the edge of the leaf as eat out holes. The caterpillars are largely nocturnal, remaining in clusters on limbs and trunk, or hiding in some crevice during the day, and beginning between 7 and 8 o'clock in the evening leisurely to ascend the tree, where they feed on the foliage at intervals during the night, descending about 3 o'clock in the morning.

"The larvae transform to pupae during the month of June, the moths appearing from the latter part of June till the latter part of July. In exceptional cases these dates may be considerably extended. Males emerge in advance of the opposite sex, and shortly afterwards the females appear, pairing takes place and egg deposition begins. The embryos are frequently well developed within the egg in two or three weeks after oviposition, but as a rule the caterpillars do not emerge till the next spring. A case is on record of eggs hatching in early September, 1895, at Woburn, Mass., but the round of life was not completed, and in this northern latitude at least, there need be little fear of two generations annually."*

The insect feeds upon the foliage of practically all of the shrubs and plants grown for economic and ornamental purposes.

Concerning recommendations for combatting this pest, Dr. Felt has the following to say:

"Investigate anything that arouses a suspicion that it may be the gypsy moth, but be in no undue haste to identify the insect. It will be much more satisfactory to submit the specimens to an entomologist than to arouse unnecessary fears. There have already been several false alarms occasioned by persons with more enthusiasm than discretion, who have attempted to identify an insect with which they were unacquainted.

"It would undoubtedly pay to exterminate a small colony, but in the course of time this will be impracticable. We must learn to control it on our own land. The inability of the female to fly and the conspicuousness of the egg-masses make this task relatively easy, unless the pest is allowed to escape to the woods. There, a private individual could hardly cope with the insect. The point of establishment in this state is almost bound to be near some dwelling, and therefore the species need not be allowed to establish itself in wild land, at least for some years.

"One of the most effective methods of keeping this pest under control is the careful collection and burning of the conspicuous egg-masses. This can be done most effectually in the fall, during the winter and in early spring. No ordinary fire running over the ground can be relied on to kill the eggs. The only safe way is to put them in a stove or similar fire and burn them. Creosote oil applied to the egg-mass will soak in and kill the eggs. The following preparation was used in the work against the gypsy moth: Creosote oil, 50 percent; carbolic acid, 10 percent; spirts of turpentine, 20 percent, and 10 percent of coal tar. The latter was added to color the compound and thus show at a glance what clusters had been treated."†

*Insects Affecting Park and Woodland Trees. N. Y. State Museum Memoir 8.
†Ibid.

"The caterpillars prefer to hide during the daytime, and advantage may be taken of this habit to tie burlap bands in the middle around the tree trunks and then turn the upper portion of the burlap down over the string. The bands can be lifted daily and the caterpillars beneath killed. This method proved of such great value in the work against the gypsy moth that thousands of trees were banded during the latter part of the caterpillar season."

"The larva is quite resistant to arsenical poisons, and it requires a large dose to kill it, especially when the caterpillar is nearly grown. There is probably no better poison for this pest than arsenate of lead, using at least 5 pounds to every 50 gallons. The application should be made as soon as the leaves are well grown, and then the caterpillars will be poisoned while young and most susceptible to the insecticide."

Spiny Elm Caterpillar or Mourning Cloak Butterfly, Evanessa antiopa Linn.

The adult of this species is one of the butterflies quite commonly seen flying about. It is strikingly marked by the general dark-brown color of the wings being bordered by a margin of broken yellow, the whole general appearance being that of black bordered with white.

The eggs are deposited in rings around the twigs of the food plant, which for Ohio is usually willow, though elms are sometimes attacked. The full grown larva is black with a row of red spots down the back. It bears numerous long spines which in turn bear shorter branches. It measures about two inches in length. The pupal stage is passed as an unprotected chrysalid attached to some portion of the food plant. The winter is passed in the adult stage in some sheltered nook.

Control methods consist in spraying with poison, or in collecting the larvae and destroying them as they feed in clusters.

Black Walnut Caterpillar, Datana integerrima Grote & Robinson.

The general body color of the larva of this insect varies from dark brown to black, and it is clothed in long, white hairs. When disturbed it suddenly raises both ends of the body to a vertical position, holding only with the body legs. This peculiarity, in combination with its general color, renders the insect comparatively easy to distinguish. The full grown larva is about 2 inches in length. It has been observed by the writer feeding on black walnut only, though it is reported from other states as feeding upon butternut, hickory and others.

The larvae feed in clusters on the leaves and at certain intervals travel to the trunk or larger branches of the tree for the purpose of molting, leaving a silken path as they go. They settle in a large

mass to cast their skins and after the completion of the operation pass back along their well marked trail to their feeding grounds. A considerable quantity of the cast skins remains attached to the tree at the point where the cluster of larvae rested. They again travel *en masse* when they pass to the ground to pupate.

The insects may be destroyed in great quantity while they are settled upon the trunk of the tree during their molting period, or the crop of insects for the following season may be considerably lessened by thoroughly working the ground beneath the tree during the winter months to destroy the hibernating pupae.

The Catalpa Sphinx, Ceratomia catalpa Bois.

This insect has been known to occur in Ohio for a number of years. It is only since the catalpa has become so popular as a tree for forestry purposes that the catalpa sphinx has attracted very much attention. Its ravages are confined mainly to the southern part of the state.

The insect, as represented in the different stages of its development by Plate 12, is most easily detected by its work upon the leaves during the larval stage. The tiny worms may be observed feeding in rows or clusters upon the epidermis of the leaf. Later the whole leaf is eaten and in case of bad attacks the entire tree is defoliated, as represented in Plate 13, Fig. 1. The larva is first of a pale yellowish-green color and bears a black horn or spine at the rear of the body. When full grown it resembles the large green tomato or tobacco worm, with the exception that the color, instead of being solid green, is green with broken black bands extending lengthwise of the body. The worms may be observed in Ohio at least twice each season—once in June and again in late summer. Possibly there are more than two broods.

The larva pupate under the surface of the soil, the pupa proper being reddish brown, and somewhat smaller than that of the tobacco sphinx. It also lacks the peculiar "jug handle" common to the other species.

The moth is of the regular sphinx type; pointed body, narrow, strong wings, large eyes, and is of a gray ashy color. The eggs are deposited in pearly masses on the under sides of the leaves. The winter is passed in the pupal stage.

Three methods of control are practicable to be used against the pest. The first is collecting the egg-masses or clusters of newly hatched larvae. The second method is spraying with arsenicals. The third, recommended in Bul. 7, Ohio Department of Agriculture, Division of Nursery and Orchard Inspection, relates to the control of the species in nurseries or plantations and consists in deep plowing at the time the insects are in the pupal stage.

The Catalpa Bud Gnat.

The work of this insect upon the catalpa was first mentioned in Bul. 7, Ohio Department of Agriculture, Division of Nursery and Orchard Inspection. During the early summer, the tender growing tips of the catalpa become swollen and in time blacken at the point of injury. During the early part of the season the injury is usually found 3 or 4 inches below the tip, and at a lesser distance during late summer when the tree is growing less rapidly. The tip above the injury dies. Following the death of the tip in early summer, the next node below develops one or more branches and frequently a cluster of leaves, giving the tree a bushy growth. Plate 24. The ultimate result after continued topping is a stunted, crooked, forked, growth—Plate 13. Fig. 2.

An examination made last spring of all the twigs upon 15 three-year-old catalpa trees revealed the fact that 49 percent of the tips of the twigs had been injured by the bud gnat.

If one of the injured twigs is examined by being cut open, small, footless, yellow or white larvae will be found. If one of these is placed on a smooth surface, it has the power to jump several inches in the air. This is accomplished by raising both ends of the body so that they almost meet above, and then with a sudden motion straightening out.

The insect has been under observation on the Experiment Station farm since the summer of 1904. From observations made in the field there appear to be two broods per annum, one in early and another in late summer. The pupal stage is probably passed under the surface of the soil, as the author was unable to secure adults by placing twigs infested with the larva in cages that did not contain moist soil.

With so little understood concerning the pest it is difficult to plan remedial measures. It has been suggested in Bul. 7, Ohio State Department of Agriculture, Division of Nursery and Orchard Inspection, that cutting the infested twigs and destroying them would be of value during the summer.

The Station plantings at Wooster indicate that the pest is less serious in cultivated groves than in sodded ones. However, this observation can only be considered as an indication, as the cultivated groves are younger than the sodded ones and the insect has thus been unable to become so well established.

The Elm Leaf Beetle, Galerucella luteola Mull.

This insect was first discovered within the borders of this state by Mr. G. A. Runner of the State Nursery and Orchard Inspecting Department. It was found during the summer of 1904 feeding upon the elms located in the grounds of the National Cash Register Co., Dayton, Ohio. Subsequent examinations revealed its presence in a number of parts of the city.

In July, 1907, the writer made a visit to the city, and found the elms in some sections to be in very bad condition. At that time, as far as the writer was able to learn, work of combatting the insect had been commenced in three places only, one being on the grounds of the Cash Register Company, where arsenical sprays had been applied, and the remaining two were near the center of the town, where some work in banding had been executed by Mr. C. F. Harbison in cooperation with the Agricultural Experiment Station.

Because of the absence of the chief gardener, in whose charge the work had been placed, the writer was unable to obtain a very definite idea of what had been accomplished towards controlling the insect on the grounds of the Cash Register Company.

The plan worked upon by Mr. Harbison was to band the trees with tanglefoot and burlap when the larvae first began to descend, and to examine the bands at frequent intervals throughout the season, destroying all larvae or pupae that collected on or under the bands or at the base of the tree. Although most carefully executed, the banding process was only partially successful in controlling the pest.

The elm leaf beetle is well distributed in the eastern states, and now annually ruins great numbers of shade trees. The green and black striped beetles, not over ⅜ inch in length, pass the winter in the adult stage in some sheltered place. With the coming of spring they leave their shelters and begin feeding upon foliage of the elm. Soon the eggs are deposited on the under sides of the leaves and within a few days the larvae appear. They feed upon the undersides of the leaves, leaving the vein work and epidermis above. Soon the injured portions of the leaf die and the leaves appear as illustrated in Plate 15, Fig. 1.

The grubs become full grown in from 2 to 3 weeks, or possibly longer, depending upon the weather conditions. At the conclusion of larval development the insects crawl about and either pupate in the crevices of the bark or in some nearby shelter. Often they may be seen lying helpless in considerable quantities at the base of the tree.

It is quite likely that only two generations occur annually in Ohio. Elms only are attacked.

Spraying with arsenate of lead, used at the rate of 5 pounds to 50 gallons of water, as soon as the young leaves are well developed is the most satisfactory remedy for combatting this pest. If the application be made at that time, many of the adult beetles will be destroyed and egg-laying prevented.

The banding process undoubtedly does considerable good, but the labor involved in watching the bands renders the cost out of proportion to the good accomplished. See Plate 15, Fig. 2.

The Locust Leaf Miner, Odontota dorsalis Thumb.

This insect has occurred in destructive numbers for several years in Ohio, the most severe attacks being upon yellow locust, both in plantings and in the wild hillside growth along the southern border of the state. It may be found in the vicinity of Wooster, but very scatteringly. Along the section bordering the Ohio River, the locusts suffer so severely as to cause the browning and shedding of the leaves, large areas appearing as if scorched by fire.

The adult is a flattened beetle about ¼ inch in length. The general color is red, broken by a medial line, with head, appendages and under surface black. The wings are deeply dotted with fine punctures.

The winter is passed in the adult stage under trash in the vicinity of the feeding ground. In the spring the beetles emerge soon after the leaves of the locust are well grown. Eggs are deposited upon the surface of the leaves, and the young larva makes its way out through the under side of the egg-shell into the tissue of the leaf, feeding until grown and pupating between the two layers of epidermis. The adults feed upon the leaves and may be found in the groves throughout the summer. The most satisfactory method of combatting the pest is spraying thoroughly with arsenicals as soon as the locust leaves are out, that the beetles may be killed before egg laying is accomplished. This of course is impracticable for forest plantings.

The Locust Borer, Cyllene robiniae Drury.

So destructive is the work of this insect upon locust trees that in some places the growing of a perfect tree is an impossibility. The adult belongs to that class of insects known as the long-horned borers. It is a black beetle, brilliantly marked with yellow lines; the long antennae and the legs are dull yellow and the length varies from 1½ to 1¾ inches.

At the time the golden rod blossoms the adults appear and egg-laying commences. The female hurries about over the trunk of the tree, and when a crevice is found which suits her fancy she deposits a single white egg, then continues her search for another place. The eggs are shown much magnified in Plate 17, Fig. 1.

The newly hatched larva bores through the outer layer of bark and rests in the white layer next the wood through the winter. With the advent of spring feeding is resumed, and the larva eats its way well into the body of the tree. If the tree is small the trunk may be almost severed and a slight wind may blow it over. See Plate 17, Fig. 2.

The full grown larva is a creamy, club-shaped, footless grub, about ¾ inch in length. See Plate 16, Fig. 2.

The pupal stage is passed within the burrow, the adult emerging at the time previously stated. There remains to be found a practicable, effective, combative measure for this pest. Spraying the trunks of the trees with a repellant just previous to the time the females deposit their eggs is of some value, though not wholly effective. Whale oil soap and white-wash were applied to adjoining rows of trees in the Station planting, resulting in a slightly lessened injury during the season following. Injecting carbon bisulphide into the tunnels, by the use of an engineer's oil can, previous to the appearance of the adults and closing the tunnels with grafting wax was also partially successful in controlling the pest.

The Locust Twig Borer, Ecdytolopha insiticiana Zell. The presence of this insect in yellow locust groves is quite easily detected by its work upon the twigs of the tree. The smaller twigs become swollen and after a time white, sawdust-like material commences to drop from an opening in the enlarged section (Plate 16, Fig. 1.) The injury is the work of a lepidopterous larva, which, upon the completion of growth, drops to the ground and pupates among the dried leaves. In this position the winter is passed. Although not exceptionally injurious it harms the tree to a certain extent. It is a question, however, whether combative measures are worth while. Should action be considered necessary, the affected twigs may be cut and burned while the larvae are still present in them, or the leaves containing the hibernating pupae may be collected and destroyed during the winter.

SPRAYING APPARATUS.

Power sprayers connected with large mixture tanks are the most practicable for general operations against shade tree pests, as only a strong pump is able to elevate the mixture to the top of tall trees, and the work in doing so is enormous if it is attempted by hand. The city of Cleveland has two of these sprayers, driven by small gasoline engines, which are giving very good satisfaction. See Plate 20, Figs. 1 and 2. One of these sprayers has a platform built above the pump and engine upon which the men stand when spraying the tops of large trees. The sides of the platform are closed, thus protecting the machinery from the spraying mixtures.

A power sprayer, such as either of the ones illustrated, is capable of supplying three lines of hose, and with the proper attention, of distributing 700 to 1000 gallons of mixture per day.

However, it is not always possible to take a large spraying outfit to the scene of operations, and in such an event a smaller machine is desirable. The outfits illustrated (Plate 19, Figs. 1 and 2) supply such a need very well.

Aside from the difficulty of application in cities, another obstacle is the matter of the preparation of the sprays. Insect outbreaks are liable to occur in widely separated districts, so that it is impossible to have a central spray-house easily accessible from all points. The difficulty is especially emphasized in the work with the lime-sulfur wash, or in fact, in the preparation of any spray requiring considerable apparatus. The problem has been largely solved by the city of Cleveland by mounting a steam boiling plant on wheels. Plate 18, Fig. 2. This rig is taken to the scene of operations and stopped near a water plug. A plant of this kind with its four barrels for boiling the mixture and heating water is easily capable of furnishing material for one power sprayer.

The rig was also used to excellent advantage in the preparation of kerosene emulsion. Plate 18, Fig. 1. The soap and water were placed in a barrel and the steam turned on until the soap was dissolved. The kerosene was then thrown in and the steam, rushing out, formed a perfect emulsion in an exceedingly short time. Such a rig is capable of furnishing emulsion for three or four power sprayers.

SPRAYING FORMULAE.

In the general application of insecticides, the materials divide themselves into two classes according to the manner in which they affect the insect. The first includes the contact sprays which are used against insects possessing mouth parts constructed for piercing the covering tissue and taking out the sap of the plant. Of this class the lime-sulfur wash, kerosene emulsion, etc., are well known illustrations. The idea in their application is to cover the body of the pest with the spraying mixture.

The second class of sprays is used against insects that bite out portions of the plant. The active element in them is some poisonous substance such as arsenate of lead, Paris green, etc. They are applied to the surface upon which the insect feeds.

CONTROL INSECTICIDES.

The lime-sulfur wash.

Lime	20 lbs.
Sulfur	15 lbs.
Water	50 gals.

The lime is placed in the boiling receptacle and water added. (preferably hot) in small quantity until slacking is well under way. The sulfur is then thrown on either dry or in the form of a paste, and water is added as necessary to keep the mass sloppy. Upon the completion of the slacking process, water to make 15 gals. is added and the whole is boiled for an hour. At the end of the boiling period water, hot or cold, is added to make 50 gals. and application is made as soon as possible. A steam cooker is more satisfactory than a kettle over a fire, as less stirring during the boiling process is necessary and the mixture thus made is more even in quality.

For more detailed instruction concerning the preparation of this wash, the reader is referred to bulletin 169 of this station.

It may be safely said of the lime-sulfur wash that it is the most generally employed of the scale-destroying sprays. In its use, however, care must be taken that the cooking is done thoroughly lest the lime and sulfur fail to combine properly, and conditions must be favorable at the time of application. The spray should not be applied when the temperature is below freezing.

Kerosene Emulsion

Kerosene	2 gals.
Soap	¾ lb.
Water	1 gal.

Heat the water and dissolve the soap in it. While boiling hot, pour into a convenient receptacle into which has previously been placed the kerosene, and agitate thoroughly until a thick creamy mass results from which the oil does not separate. A spray pump serves admirably for this purpose, as the mixture may be pumped back into itself. Where the sprayer is not available an old churn and dasher serve the purpose admirably.

After the emulsion is perfect, it may be diluted with water to the consistency desired which varies with the insect to be combatted.

Whale oil soap solution

This is a very convenient spray to use where it is not convenient to prepare kerosene emulsion. It is made by merely dissolving the soap in hot water in the proportion desired.

Kerosene-Limoid

The principle involved in the preparation of this emulsion is practically the same as in kerosene emulsion, the difference being that a very fine lime is used as the emulsifying agent instead of soap. A special kind of lime containing about ⅓ magnesia is prepared by the Chas. Warner Co., Wilmington, Del., and is called Limoid. Prof. C. P. Close of the Delaware Experiment Station reports that any dry-slacked, finely powdered lime is good for the purpose.

The kerosene and lime are mixed in the proportion of one gal. kerosene to 4 lbs. lime, or in other words, the lime is added to the kerosene until all the kerosene is absorbed. It requires from 3 to 5 minutes to thoroughly mix the mass. When the emulsion is complete, it is diluted with water and applied. For scale insects, upon which the mixture is most commonly used, the following are the proportions: kerosene 12½ gal., lime 50 lb., water 34½ gal.

Scalecide and other so-called Soluble Oils

Materials of this class require dilution with water only; usually 5 percent mixtures are recommended by the manufactures for scale applications.

In the experience of Prof. P. J. Parrott of the New York Experiment Station, mixtures containing 7 to 10 percent of oil applied to trees infested with the San Jose scale, gave results slightly inferior to those obtained from the use of boiled lime-sulfur sprays.

POISON SPRAYS.

The poison sprays in most general use at the present time are Arsenate of Lead and Paris Green. Of the two, the lead is the most expensive but the extra expense is usually justified by reason of its superior adhesive qualities and consequently longer period of efficiency after the application. The Paris green is more quickly effective than the lead.

Arsenate of Lead

This material is manufactured by a number of companies and is placed on the market under varying trade names. It is paste-like in consistency, requiring only the addition of water before use. Some brands are with difficulty dissolved, and for these the author has found the work of the process of preparation much lessened by placing the paste in a small burlap sack and, with frequent dippings in the spraying mixtures, work the materials through the cloth.

For most leaf-eating insects three pounds of material to 50 gal. is sufficient, while for others 5 to 7 lbs. to the same amount of water is more desirable.

Where it is impossible to obtain the manufactured article or for any reason undesirable to do so, arsenate of lead may be prepared after the following formula:

Acetate of lead ..... 11 oz.
Arsenate of soda ..... 4 oz.
Water..... 50 gal.

Dissolve the acetate of lead and arsenate of soda separately in 2 quarts of water each. Pour the two together and add the desired amount of water.

*Bulletin 28, New York Agricultural Experiment Station.

Paris Green Paris Green is mixed with water at the rate of one pound to 100 or 150 gal. of water. Two or three pounds of lime are added to prevent burning. The mixture settles readily to the bottom of the sprayer, rendering frequent agitation necessary.

REMARKS.

As stated at the outset, the problem of the control of shade tree pests is one to be encountered to the greatest extent in cities and towns, and is largely a municipal matter. Already steps are being taken in some cities, Cleveland being the most advanced in the matter in this state.

The city of Cleveland has authorized the Department of Forestry to extend its operations to the combatting of the shade tree pests, and to this end has commenced the purchasing of suitable apparatus for the purpose.

The personnel of the department consists of a Forester, Assistant Forester, clerks, and a number of "tree wardens." To the latter are assigned certain sections of the city. Besides their duties of planting, trimming, etc., as far as possible each is supplied with a spray pump mounted on wheels which he uses to the best of his ability. The two large power sprayers, before mentioned, travel about over the city to the points where the work is most needed.

At present the work of the department is confined to the street and park plantings. It is very necessary, however, that the Department be allowed to expand, until it is able to care for trees on private grounds as well, as it loses much of the good effects that should follow the work, because treated trees are reinfested by adjoining untreated ones. Possibly a fair sum could be charged the property owners for the service rendered.

It is evident that all cities and towns cannot afford such an institution as the Cleveland department, but it is the author's opinion that the public sprayer most nearly approaches the solution of the shade tree insect problem for the cities and towns of our state.

ACKNOWLEDGEMENTS.

The author wishes to express his appreciation to Prof. H. A. Gossard, Entomologist of the Station for his suggestions and approval of plans for work; to Mr. M. H. Horvath, former City Forester of Cleveland, and to Mr. John Boddy, the present Forester, for their cooperation with the Experiment Station in the conducting of experimental work, and to Mr. C. R. Neillie, of the same department, for being accorded the opportunity from time to time to examine the records of the work done by the power sprayers; and to Mr. W. H. Goodwin for preparation of one or two of the illustrations, among them the cover cut.

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EXPLANATION OF PLATE I.

Fig. 1. The oyster shell bark louse much enlarged.

Fig. 2. The oyster shell bark louse enlarged two diameters.

Fig. 3. Branch of horse chestnut defoliated by oyster shell bark louse.

Fig. 4. Scurfy bark louse much enlarged.

Fig. 5. Scurfy bark louse, enlarged two diameters.

PLATE I.

Fig. 1.

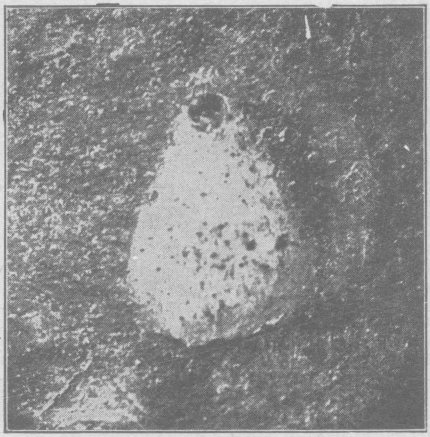


Fig. 4.

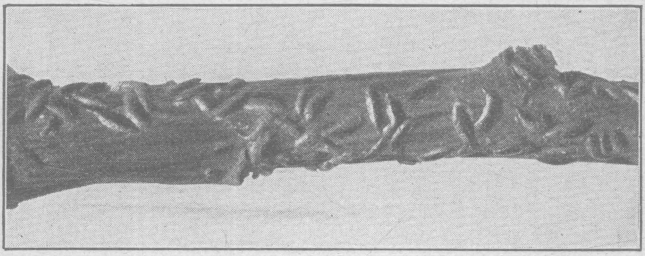


Fig. 2.

Fig. 5.

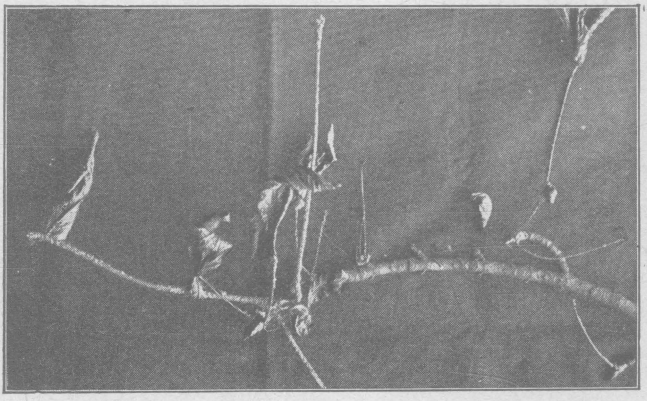


Fig. 3.

EXPLANATION OF PLATE II.

Fig. 1. The rose scale, natural size.

Fig. 2. The maple cottony scale, natural size.

Fig. 3. Lombardy poplar on the campus of Buchtel College, Akron, Ohio. This tree is badly infested with oyster shell bark louse. The horse chestnut is badly infested at the base; the next in order a little less so; the next one a little less, etc., down the line. It is a most striking illustration of how scale insects spread from a badly infested center.

PLATE II.

Fig. 1.

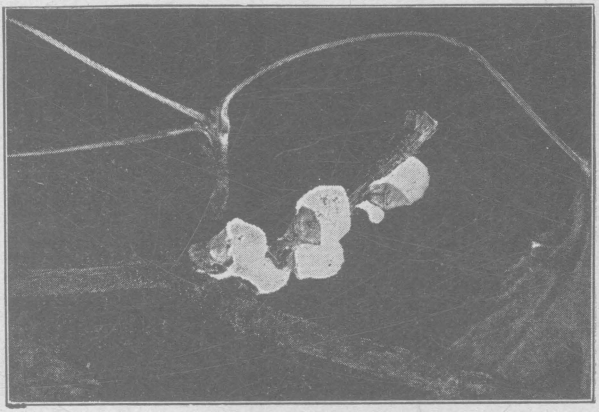


Fig. 2.

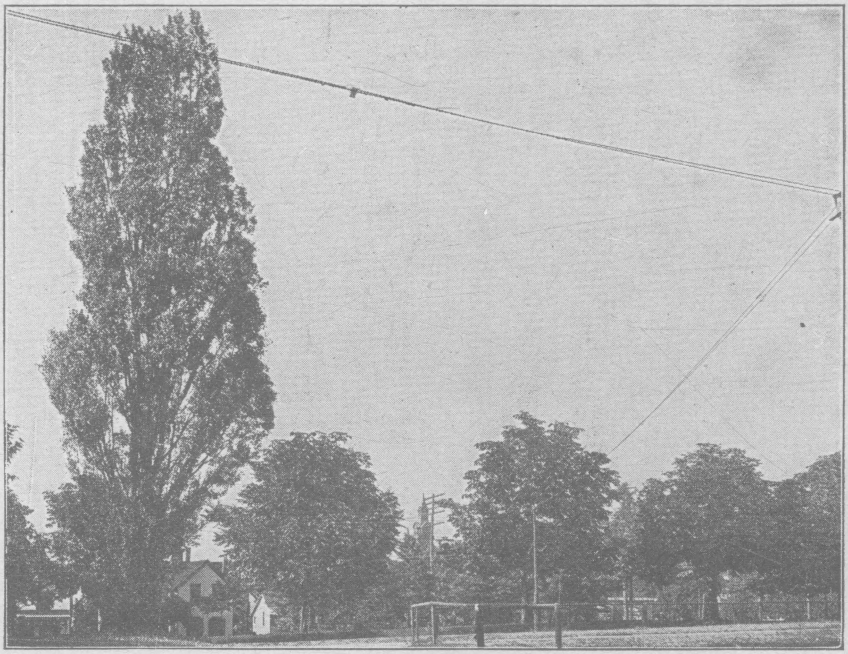


Fig. 3.

EXPLANATION OF PLATE III.

Fig. 1. The pine leaf scale, natural size, with the twice-stabbed lady bird, *Chilocorus bivulnerus* Muls., feeding upon the scales.

Fig. 2. Adult females of the elm bark louse.

Fig. 3. The pine bark aphid upon the base of a pine.

PLATE III.

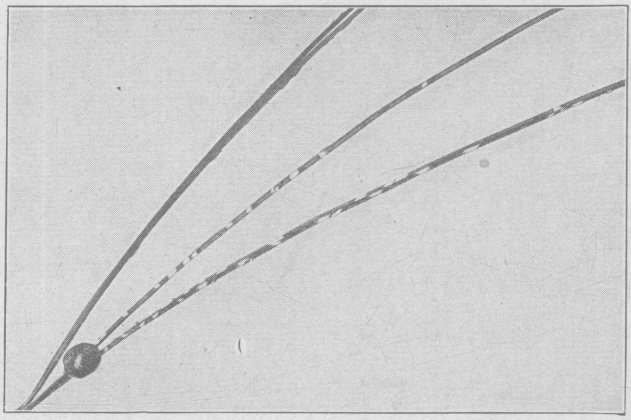


Fig. 1.

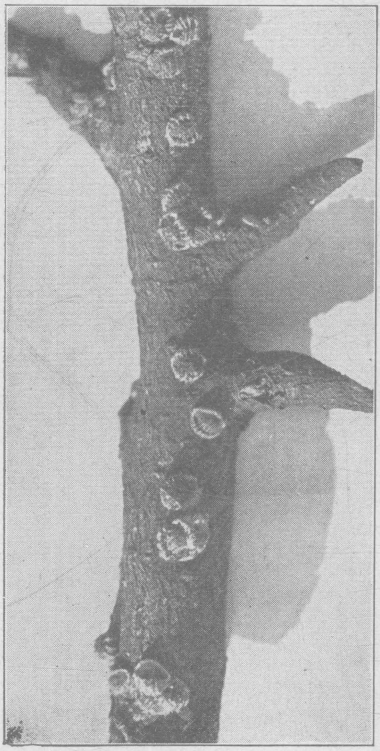


Fig. 2.

Fig. 3.

EXPLANATION OF PLATE IV.

Fig. 1. Hard maple sprayed during the early spring with kerosene emulsion containing 40% kerosene. The tree was severely injured.

Fig. 2. Hard maple sprayed with kerosene emulsion containing 20% kerosene Uninjured.

PLATE IV.

Fig. 2.

Fig. 1.

EXPLANATION OF PLATE V.

Fig. 1. Egg mass of white marked tussock moth.

Fig. 2. Adult female moth about to oviposit upon her empty cocoon. Slightly reduced.

Fig. 3. Full grown larva

Fig. 4. Mass of cocoons spun in a cavity on the underside of a branch of horse chestnut.

PLATE V.

Fig. 1.

Fig. 2.

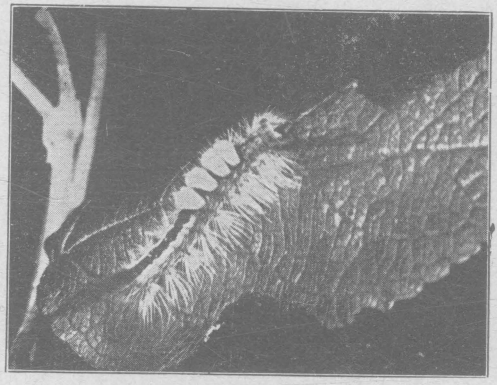


Fig. 3.

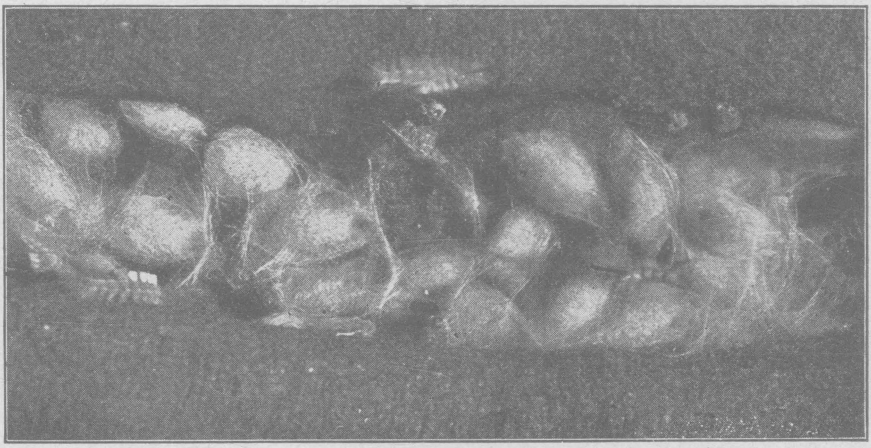


Fig. 4.

EXPLANATION OF PLATE VI.

Fig. 1. Horse chestnut photographed July 20, 1906, after it had been defoliated by the first brood of tussock moth larvae. The larvae, at the time the photograph was taken, were transforming to the pupal stage, many having already completed the operation. The tree was sprayed with strong kerosene emulsion and banded with tanglefoot.

Fig. 2. The same tree, as above described, 40 days later. Evidently most of the larvae were destroyed by the treatment, as the tree had grown a partial second crop of foliage. Compare with Fig. 2, Plate VII.

PLATE VI.

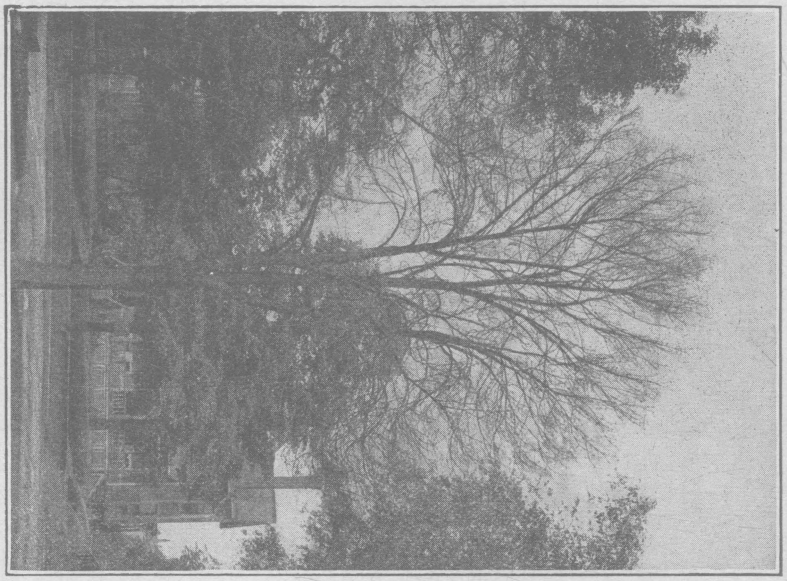


Fig. 1.

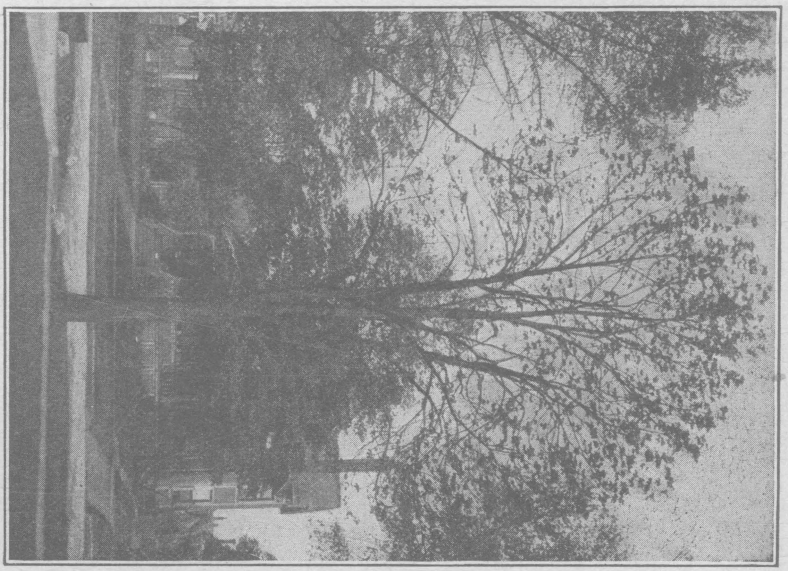


Fig. 2.

EXPLANATION OF PLATE VII.

Fig. 1. Elms protected from tussock moth by spraying with arsenicals supplemented with banding.

Fig. 2. Elm growing beside the one represented in Plate IX, Fig. 2. Untreated. Photo Aug. 30, 1906.

PLATE VII.

Fig. 1.

Fig. 2.

EXPLANATION OF PLATE VIII.

Fig. 1. An ash tree perfectly sprayed with lime-sultur wash.

Fig. 2. An elm protected from tussock moth by collecting the egg-masses during the winter.

PLATE VIII.

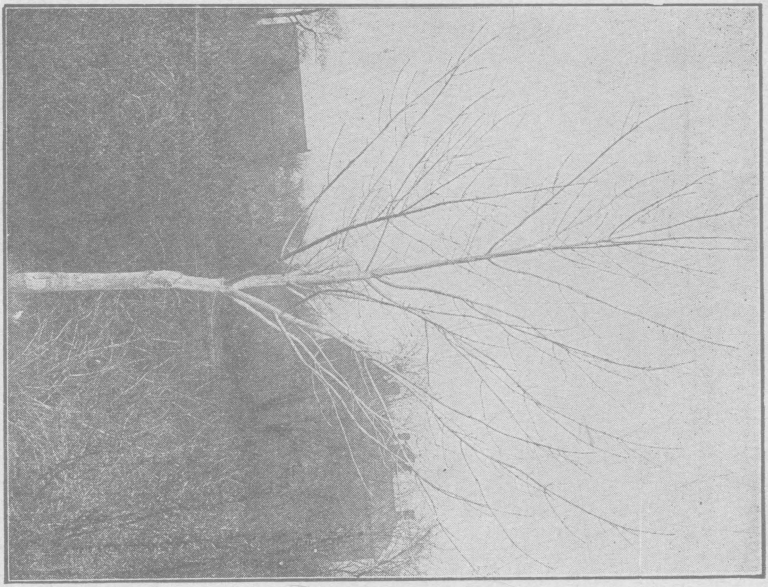


Fig. 1.

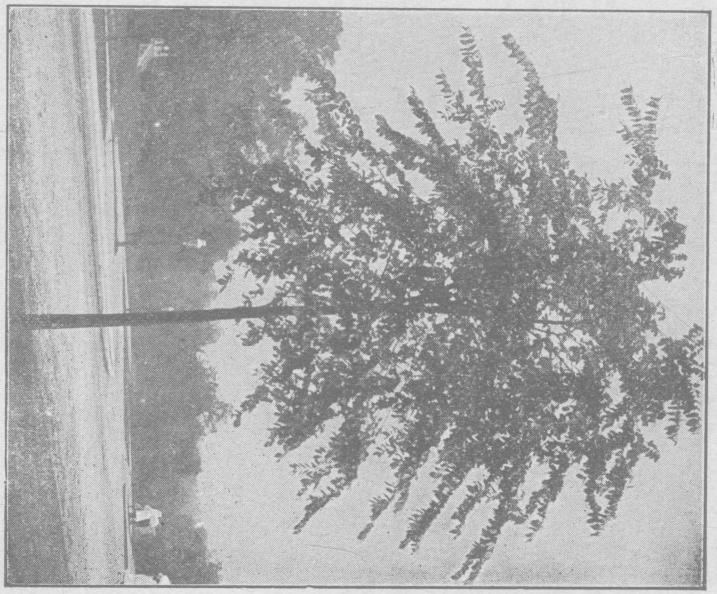


Fig. 2.

EXPLANATION OF PLATE IX.

Fig. 1. Elms located in Washington Park, Cincinnati, Ohio, defoliated by tussock moth July, 1907.

Fig. 2. Sycamore near Howard Street Station, Akron, defoliated by fall web worm.

PLATE IX

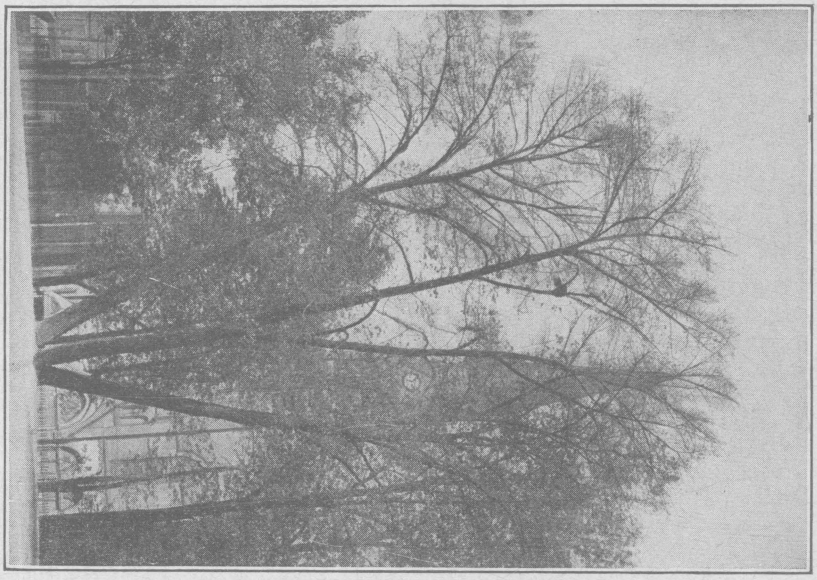


Fig. 1.

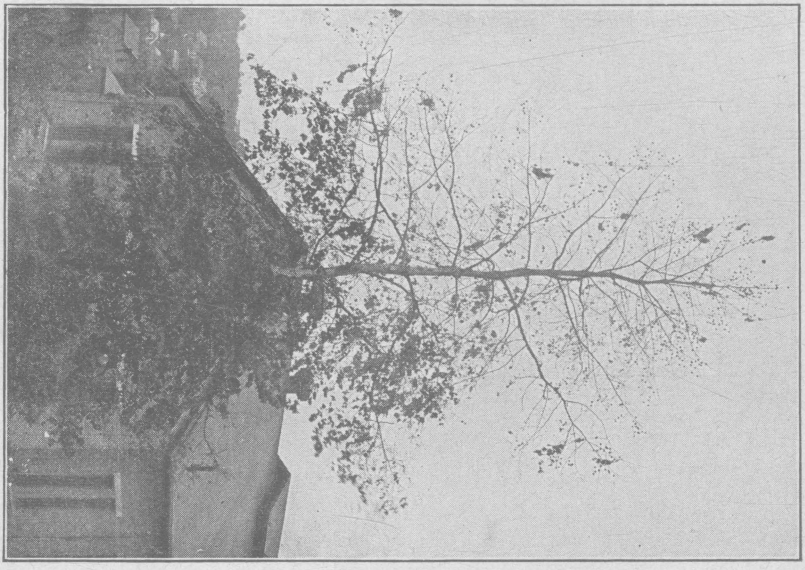


Fig. 2.

EXPLANATION OF PLATE X.

Fig. 1. Bags of bag worm on arborvitae. Photo by Newell.

Fig. 2. Branch of hard maple badly injured by bag worm. July, 1907.

PLATE X.

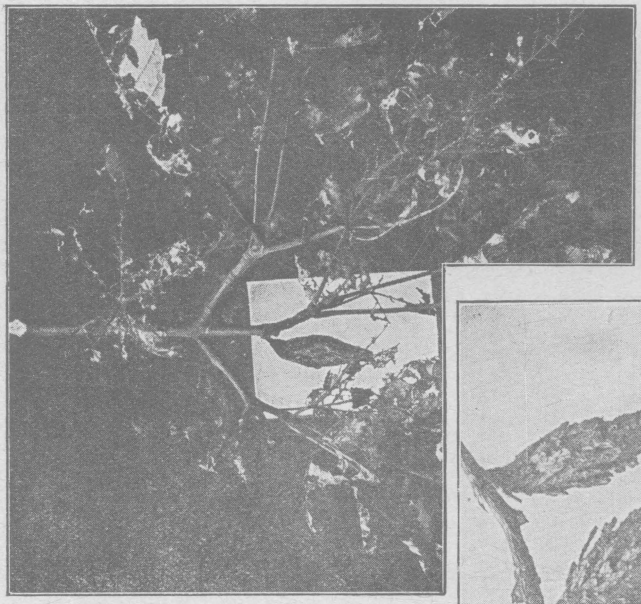


Fig. 2.

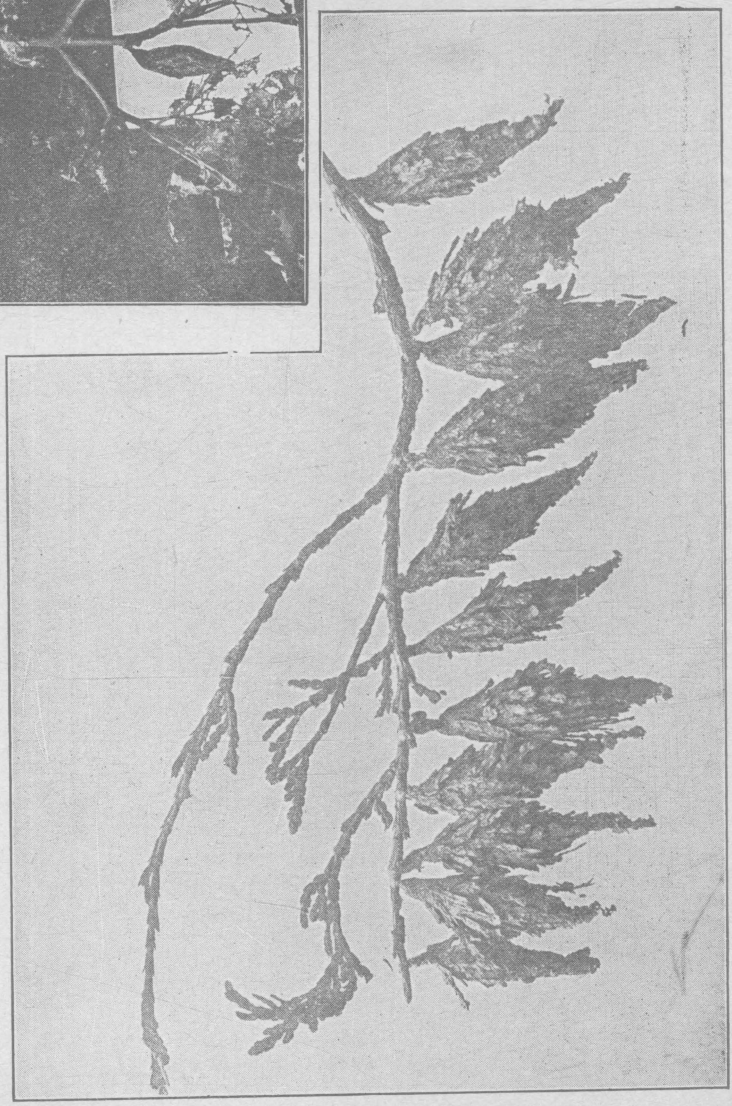


Fig. 1.

EXPLANATION OF PLATE XI.

Fig. 1. Sycamore injured by bag worm. Columbus, Ohio, July. 1907.

Fig. 2. Hard maple, Cincinnati, Ohio, injured by bag worm, July, 1907.

PLATE XI.

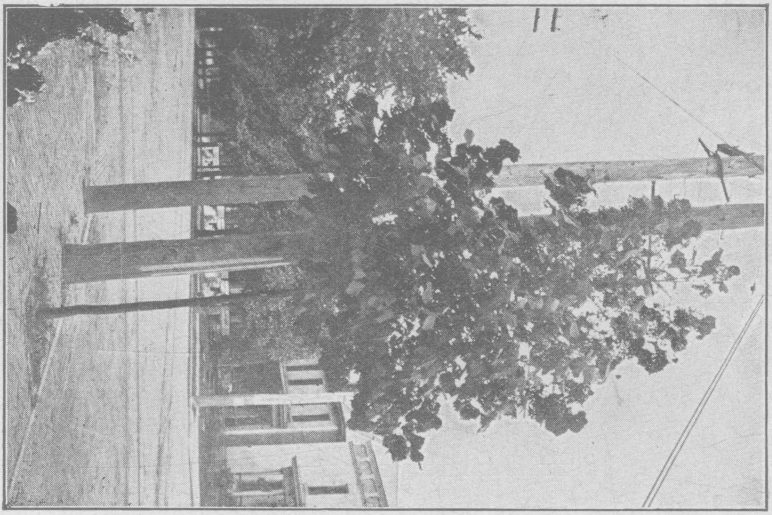


Fig. 1.

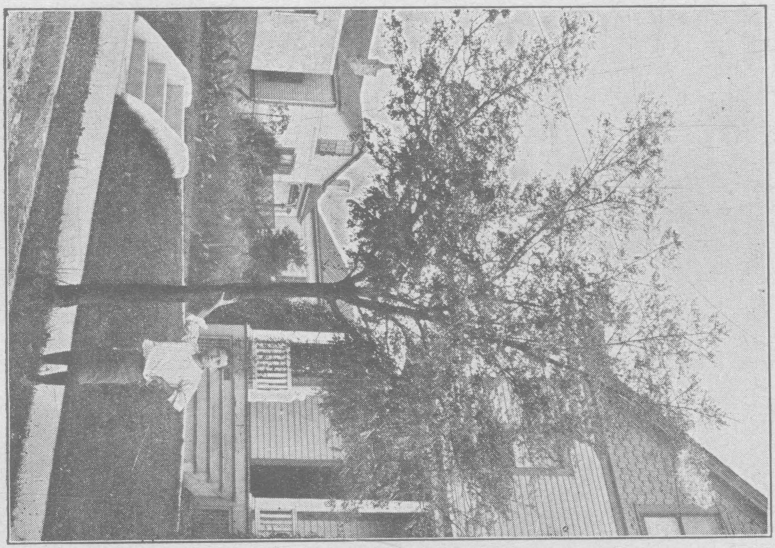
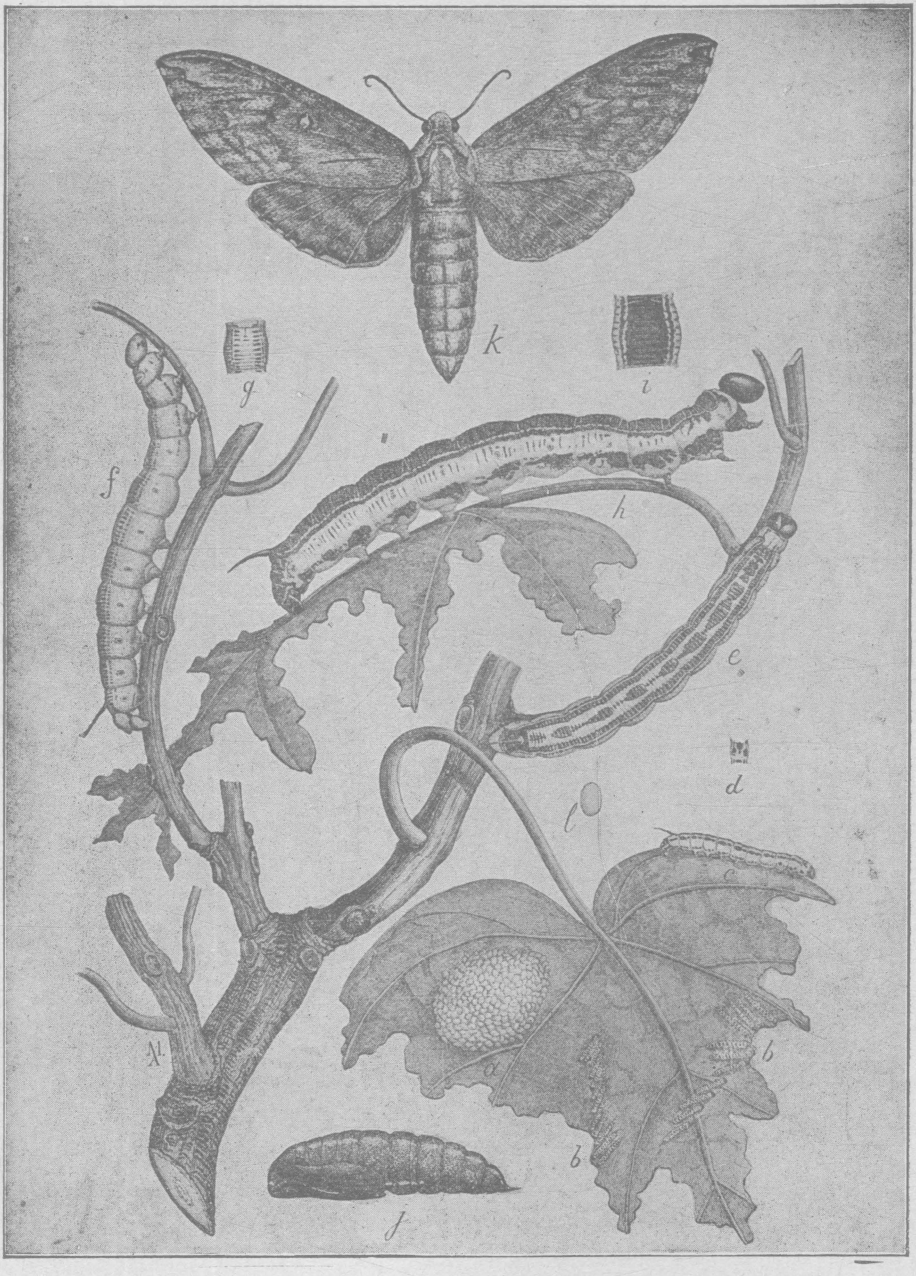


Fig. 2.

EXPLANATION OF PLATE XII.

The Catalpa Sphinx: a, egg-mass; b, newly-hatched larvae; c, a larva one-third grown; d, dorsal view of one its joints; e, f, h, differently marked larvae; g, dorsal view of one of the joints of f; i, do. of h; j, pupa; k, moth, natural size; l, egg enlarged. (From Riley, Rept. U. S. Commissioner of Agriculture, 1881.)

PLATE XII.



EXPLANATION OF PLATE XIII.

Fig. 1. Young catalpa on the farm of Mr. Clymer, Chillicothe, Ohio, defoliated by Catalpa Sphinx July 2, 1906.

Fig. 2. A catalpa tree illustrating the characteristic stunted growth following the successive injuries to the tips of the twigs by the Catalpa Bud Gnat.

PLATE XIII.

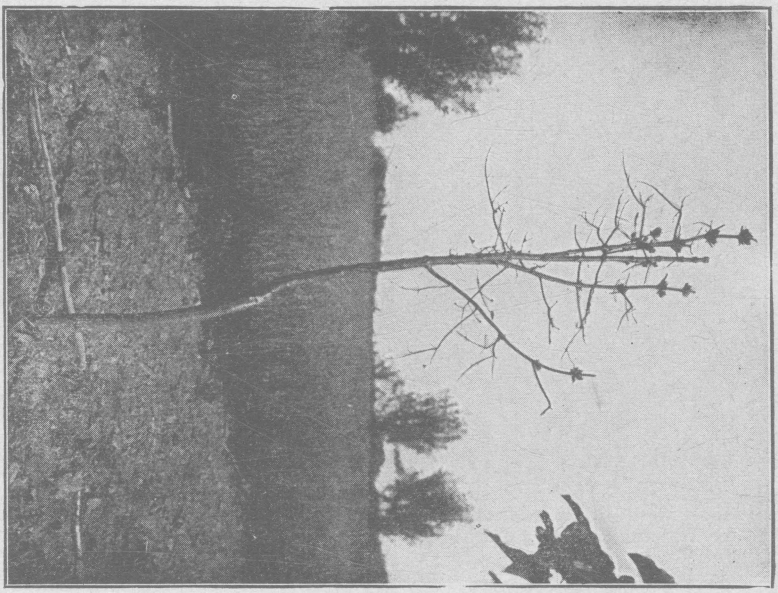


Fig. 1.

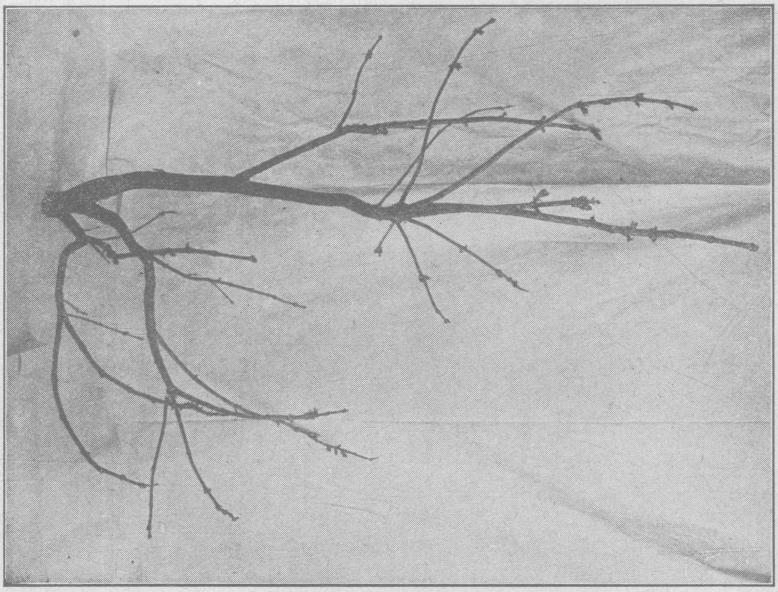
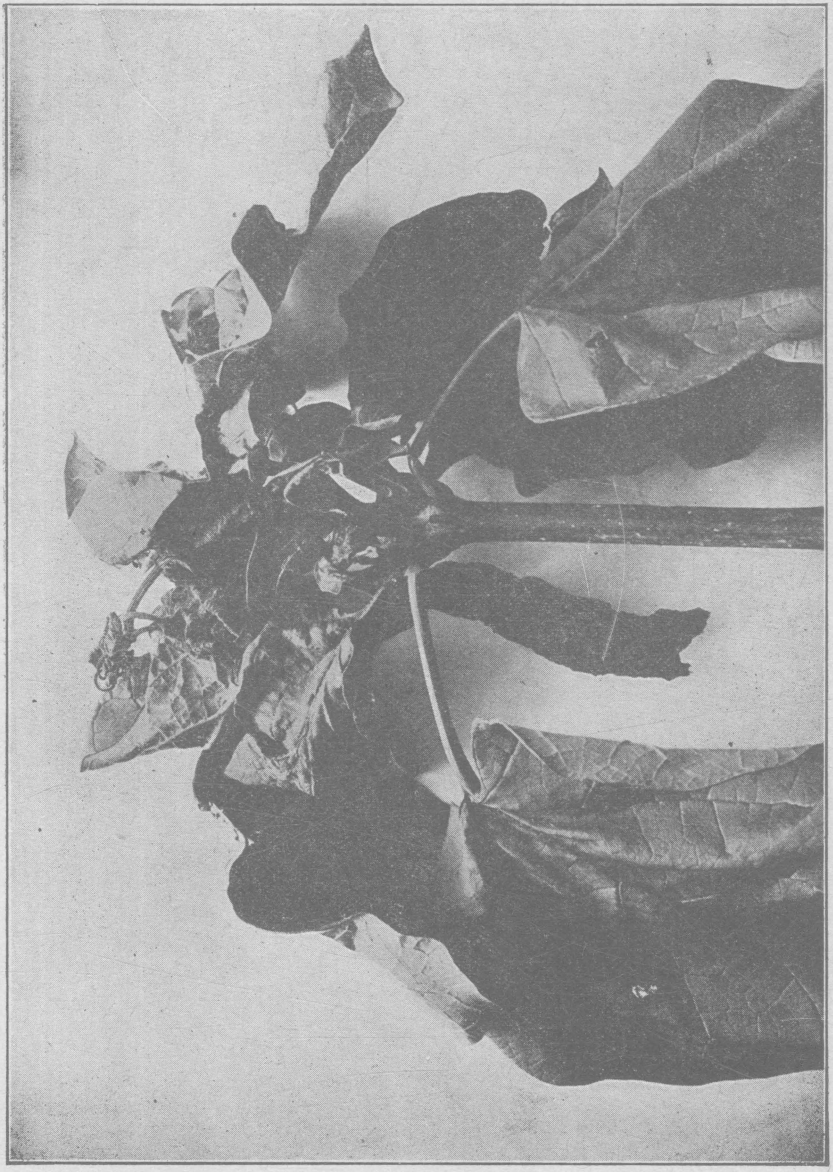


Fig. 2.

EXPLANATION OF PLATE XIV.

The top of a young catalpa tree illustrating the characteristic bushy growth which follows injury by the Catalpa Bud Gnat to the growing tip.

PLATE XIV.



EXPLANATION OF PLATE XV.

Fig. 1. Elm leaves injured by the Elm Leaf Beetle.

Fig. 2. Elm tree infested with the Elm Leaf Beetle during the season of 1906. The tree was banded with burlap and tanglefoot and the larvae collected and destroyed at frequent intervals. Photographed July, 1907.

PLATE XV

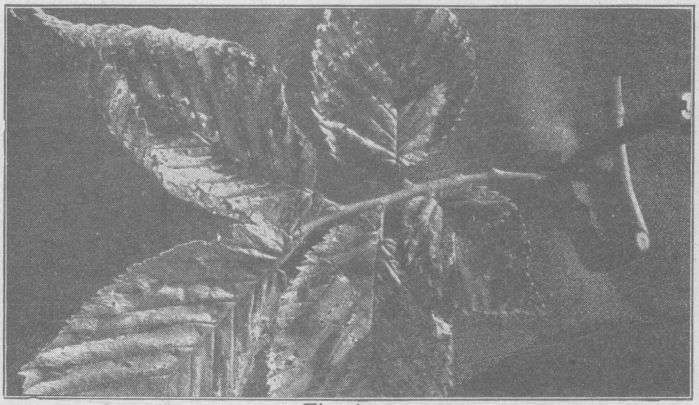


Fig. 1.

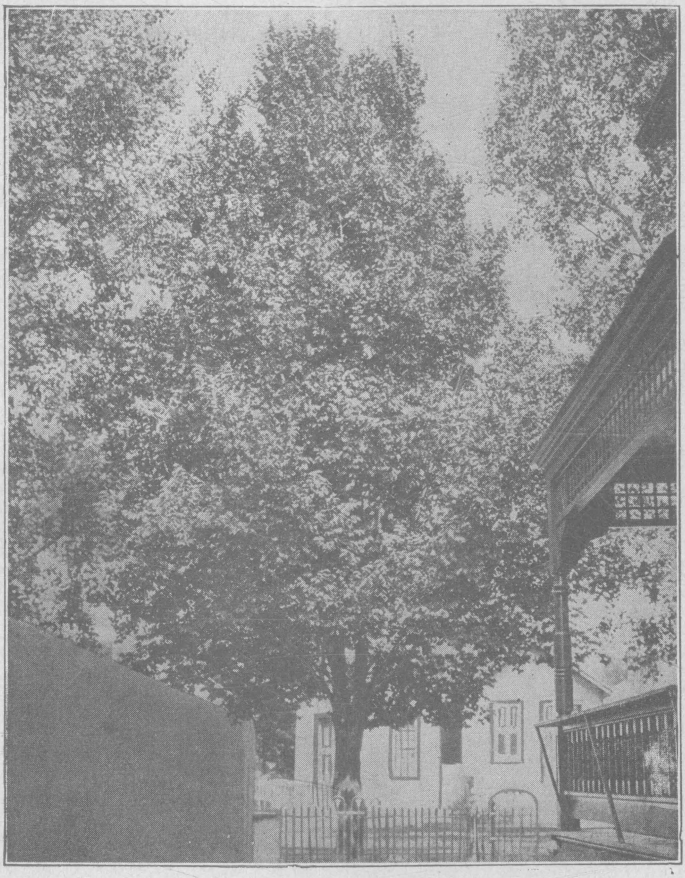


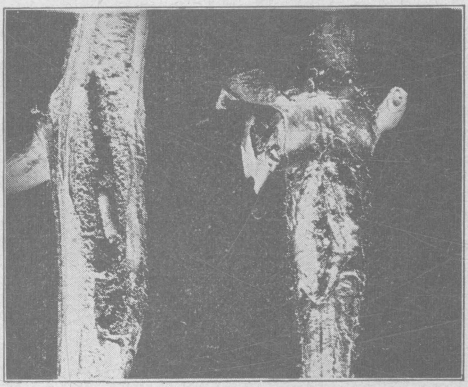
Fig. 2.

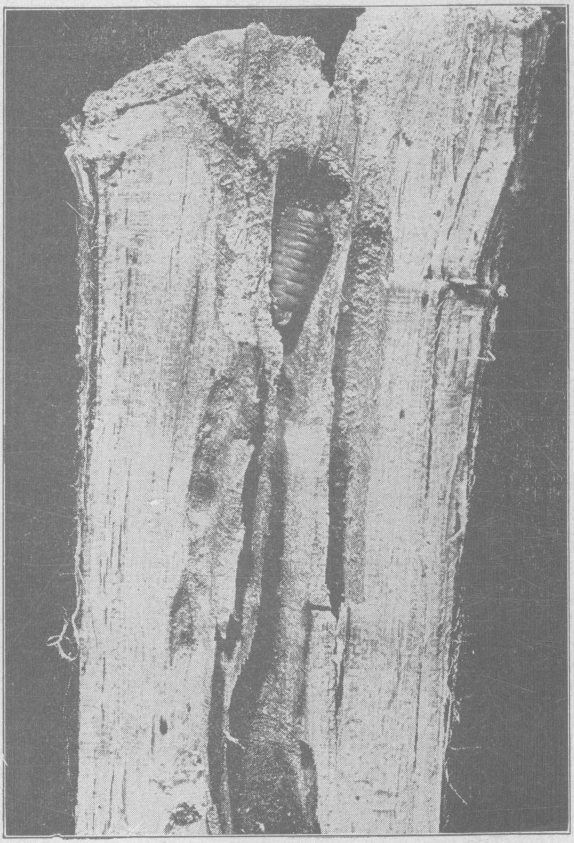
EXPLANATION OF PLATE XVI.

Fig. 1. The Locust Twig Borer, showing larvae in boring, and the characterlstic swollen twig.

Fig. 2. Larva of the Locust Borer in the body of a young locust tree.

PLATE VVI.



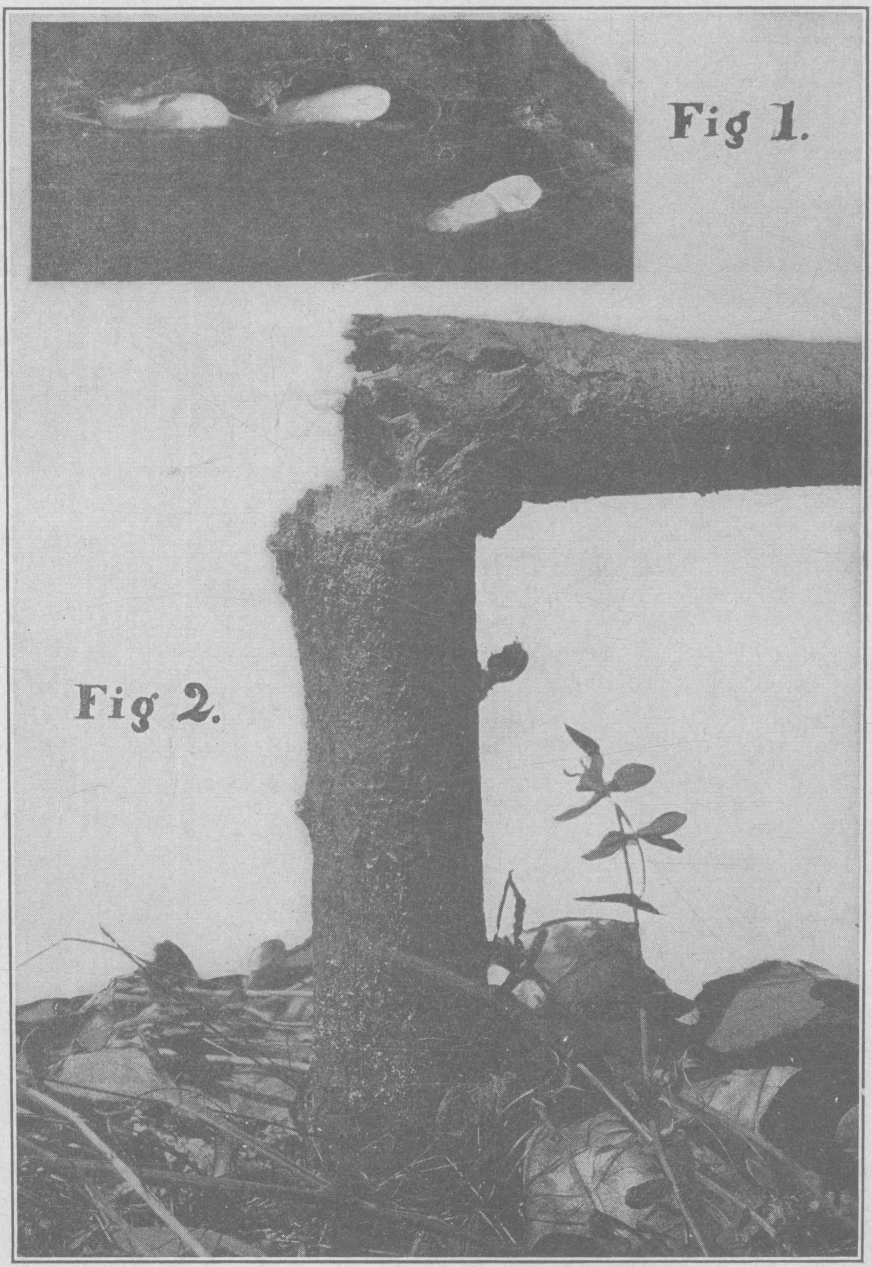


EXPLANATION OF PLATE XVII.

Fig. 1. Eggs of Locust Borer, much enlarged.

Fig. 2. Young locust tree injured by the Locust Borer, and subsequently broken by the wind.

PLATE XVII.



EXPLANATION OF PLATE XVIII.

Fig. 1. Preparing kerosene emulsion by the use of a steam boiling plant, capable of preparing 3000 to 4000 gallons of first-class emulsion per day.

Fig, 2. Same rig as above, being used for boiling lime sulfur wash. Used by the Department of Forestry, Cleveland, Ohio.

PLATE XVIII.

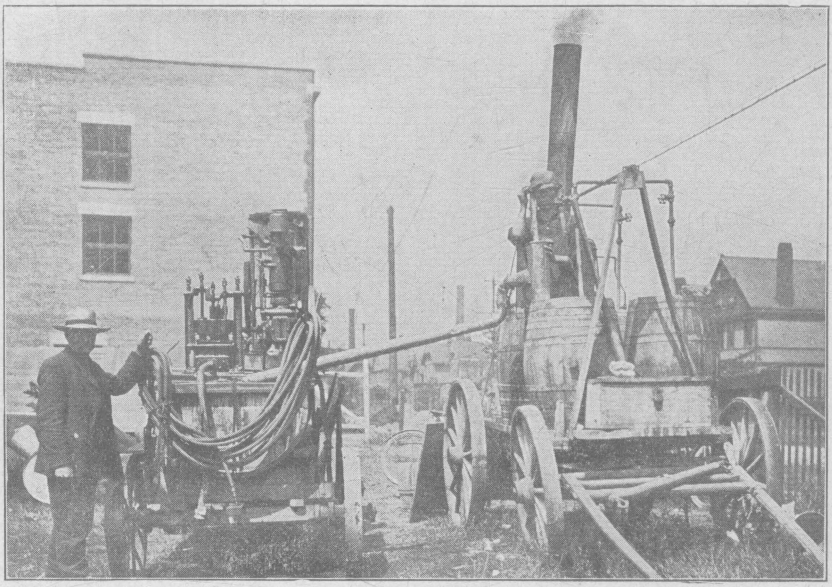


Fig. 1.

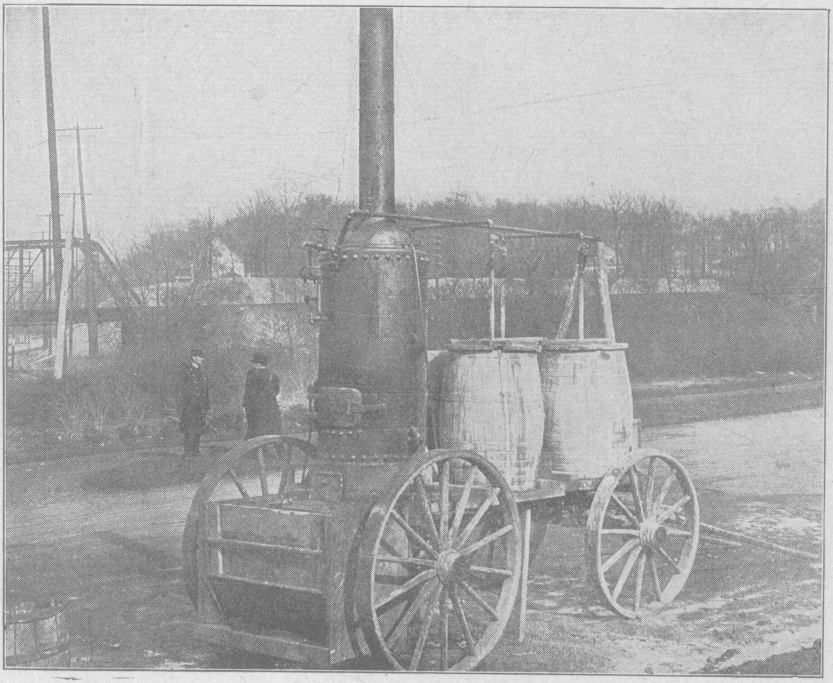


Fig. 2.

EXPLANATION OF PLATE XIX.

Figs. 1 and 2. Hand sprayers used by the Department of Forestry, Cleveland, Ohio, Fig. 2 represents a most excellent rig, durable, easily portable and capable of furnishing good pressure.

PLATE XIX.

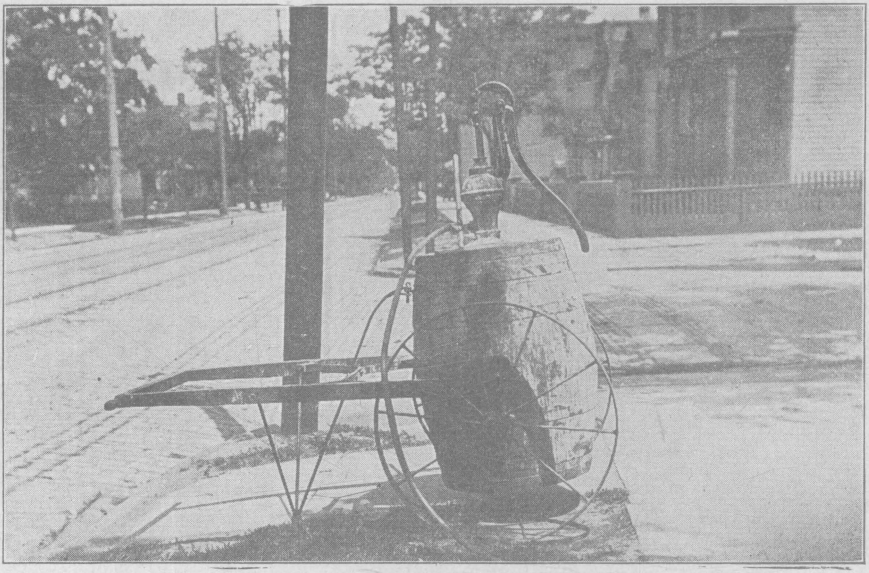


Fig. 1.

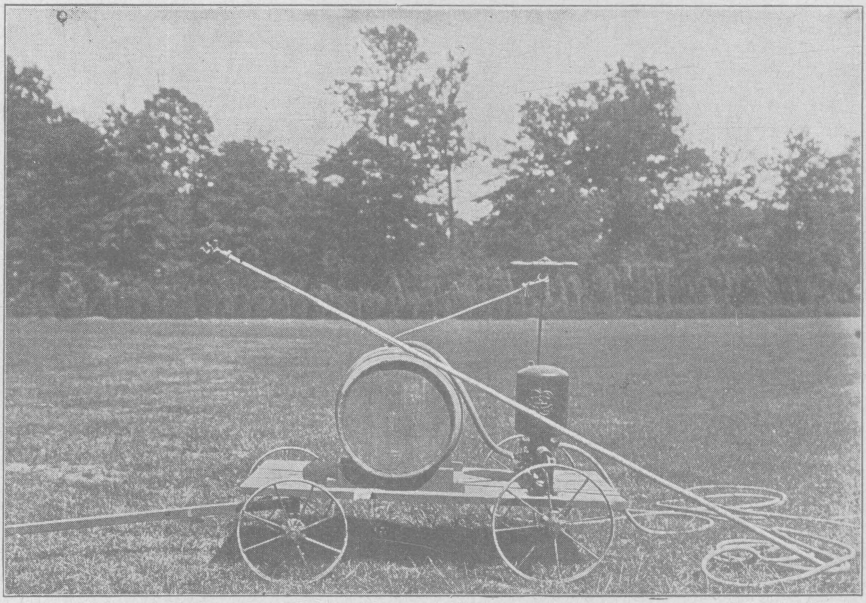


Fig. 2.

EXPLANATION OF PLATE XX.

Power sprayers used by the Department of Forestry, Cleveland, Ohio. Fig. 2 is the better of the two rigs.

PLATE XX.

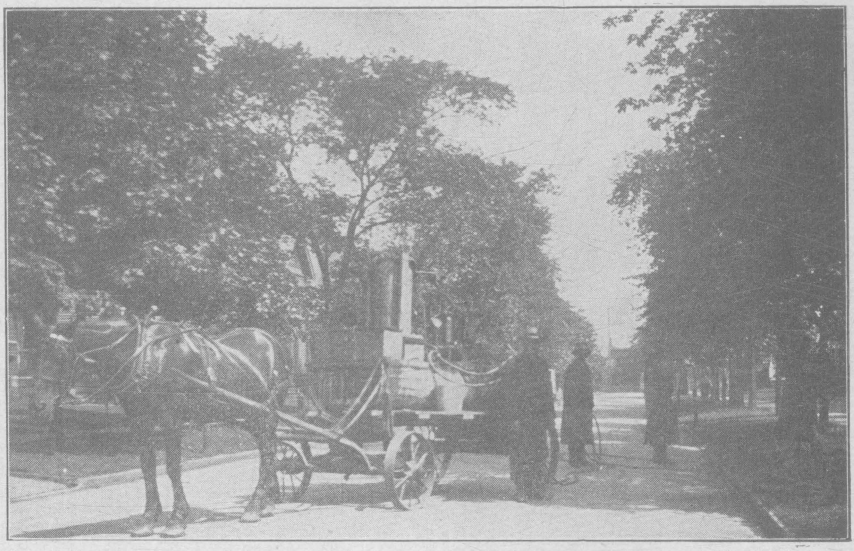


Fig. 1.

Fig. 2.

EXPLANATION OF PLA1E XXI.

Fig 1. An elm tree, Cleveland. Ohio in bad condition, resulting likely from gas poisoning.

Fig 2 An Ailanthus tree, Cincinnati, Ohio. The Ailanthus is a most excellent tree for street planting as it is almost immune from insect attack and thrives even though the roots are completely paved over as was the case of the tree illustrated. Smoke seems to have little effect upon this species.

PLATE XXI

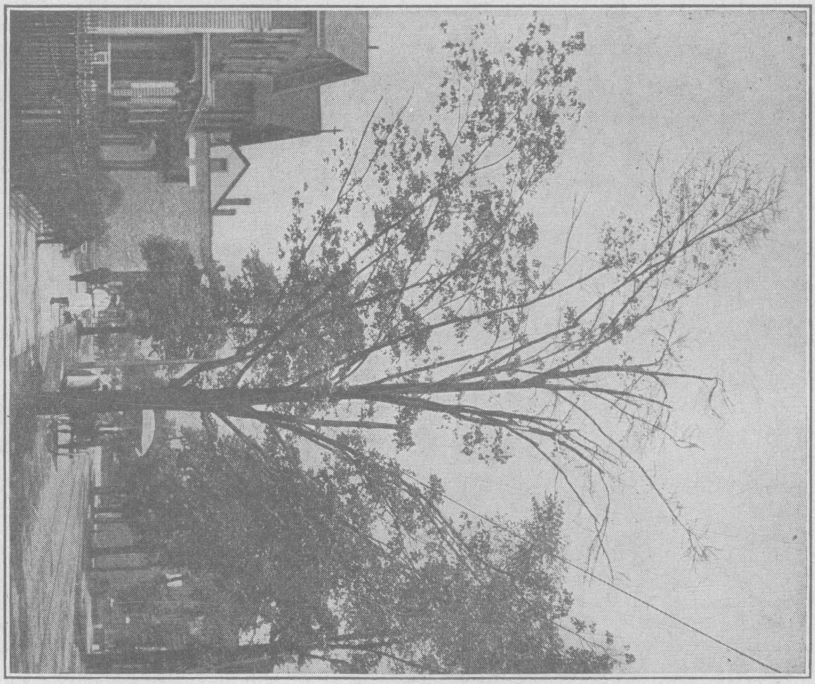


Fig. 1

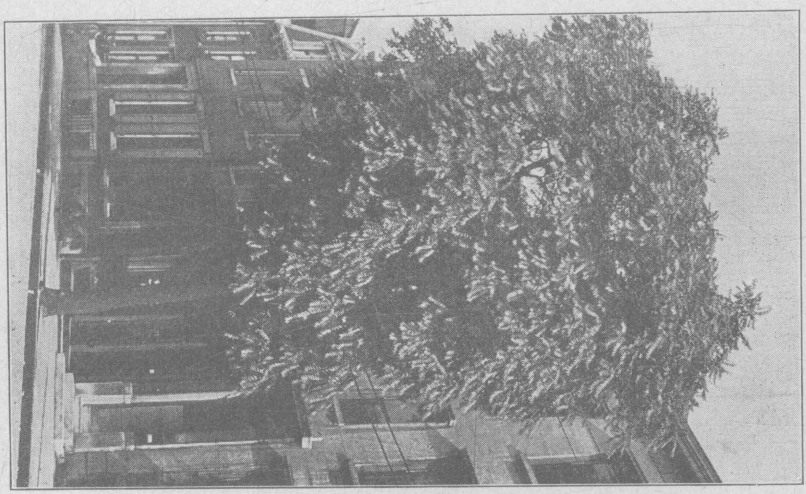


Fig. 2

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